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NASA AUTHORIZATION FOR FISCAL YEAR 1986

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

NINETY-NINTH CONGRESS

FIRST SESSION

ON

NASA AUTHORIZATION FOR FISCAL YEAR 1986

FEBRUARY 26, MARCH 27, 28, APRIL 3 AND 4, 1985

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NASA AUTHORIZATION FOR FISCAL YEAR 1986

TUESDAY, FEBRUARY 26, 1985

U.S. Senate,
Committee on Commerce, Science, and Transportation,
Subcommittee on Science, Technology, and Space,
Washington, DC.

The subcommittee met, pursuant to notice, at 9 a.m., in SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

Staff members assigned to these hearings: Peter Perkins, professional staff member, and Marty Kress, minority professional staff member.

OPENING STATEMENT BY SENATOR GORTON

Senator Gorton. I am pleased to chair this first of a series of hearings of the Subcommittee on Science, Technology, and Space on the fiscal year 1986 authorization for NASA.

Today we will hear testimony from two NASA officials. NASA Administrator Jim Beggs will present an overview of NASA's Aeronautical and Space Programs, and Associate Administrator of Space Flight Jesse Moore will discuss NASA's Space Transportation System.

Now, the fiscal year 1986 budget request generally represents a balanced and vigorous approach toward maintaining our preeminence in aeronautics and space. The new start approval for the orbital maneuvering vehicle is an important step toward extending our capabilities beyond the shuttle and the proposed station.

NASA's newly created Office of Commercial Programs is significant in that it provides a greatly needed focal point for the expanding theater of commercial space activities. It is the subcommittee's hope that this new office will provide an institutional foundation which will facilitate the evolution of commercial space development into a vibrant reality.

For the most part, the space science and applications budget request reflects strong support for its ongoing major programs. I note with concern, however, the absence of any new starts in the space science and applications request, and just as importantly, the potential problem this creates for fiscal year 1987, when several equally important science and applications programs will seek new start approval.

An unfortunate result of this potential bottleneck of new programs is that, once again, some programs could be forced to wait yet another year, a delay that could prove costly to some of those programs. I hope that during this year's authorization process this situation can be ameliorated without sacrificing the goals of fiscal responsibility and scientific balance.

As NASA prepares to move into its definition studies for the permanently manned space station, the subcommittee will examine the present budget request in the context of the program's overall goals and objectives, and in the context of wise and efficient management of the program's resources.

This subcommittee recognizes that both the management plan and the magnitude of the space station program represent major challenges for NASA in the definition phase as well as in the development phase. The subcommittee encourages NASA extensively to involve the program participants and potential users to the maximum extent possible during the definition phase as a means of avoiding unnecessary cost overruns later in the program.

While NASA's aeronautical research and technology programs have provided for decades an unsurpassed technological foundation for our Nation's civil and military aeronautical sectors, we should not overlook the fact that the gap of our technological superiority is narrowing. This should be a signal that the direction and resources of NASA's aeronautical research and technology programs warrant our most careful and judicious supervision.

Clearly, these are some of the issues in which this subcommittee has significant interests. We now have present with us Senator Hollings, and I would be delighted to defer to him for an opening statement.

OPENING STATEMENT BY SENATOR HOLLINGS

Senator HOLLINGS. Thank you, Mr. Chairman.

I just want to welcome both Mr. Beggs and Mr. Jesse Moore and others.

Mr. Chairman, I have long been interested in budgets and in the budget process. You might attribute that inclination to my experience as Governor of South Carolina, to my fiscally conservative upbringing, or to my tenure as chairman of the Senate Budget Committee. At a time when there is a broad base of support for a budget freeze, a concept I initiated in 1982, the NASA fiscal year 1986 budget request has managed to clear OMB with an increase of more than 5 percent over the fiscal year 1985 baseline. Mr. Beggs, that speaks highly of both the value of your programs and your ability to negotiate. I'm certainly impressed. And I look forward to your testimony today.

I would like to extend my personal welcome to Mr. Jesse Moore. This is his first appearance before the Committee as the Associate Administrator for Space Flight. I have heard nothing but high praise for Mr. Moore's performance to date, and I look forward to working with him in the future. I also might note that Mr. Moore is also a distinguished graduate of the University of South Carolina.

Mr. Chairman, the fiscal year 1986 NASA budget request is for $7.886 billion or for approximately 5.3 percent more than the fiscal year 1985 baseline. The principal increases in this budget are for the space station, shuttle operations, and space science and applications. I want to stress right here that these are activities which I support. However, in the course of our hearings with NASA, I hope we might be able to discover some fiscal year 1986 savings. At a minimum, I would hope we could find enough to preclude the proposed 5 percent pay cut for NASA's civilian employees. At a maximum, I would hope we find enough to ensure that NASA can make a sizable contribution toward eliminating our budget deficit.

Due to my long-standing interest in the civilian space program and in this Nation's technological preeminence, I have, in the past, been generally supportive of increases for NASA. I believe research and development stimulates the economy, creates new jobs, bolsters the Treasury, and enhances the world posture of the United States.

However, unless the U.S. Congress is willing to make the difficult choices necessary to reduce the deficit, I am fearful that our economy will go into a tailspin and the foreign trade deficit will be further exacerbated. Therefore, I will wait until the completion of the five scheduled NASA hearings before I commit myself one way or another to the fiscal year 1986 NASA budget request.

In a recently released Congressional Budget Office Report entitled "Reducing the Deficit: Spending and Revenue Options," two cost saving measures were proposed for NASA. One pertains to civil aeronautics research and development, the other to the space transportation system. Hopefully, Mr. Beggs and Mr. Moore will give us their assessment of these two options during today's hearing.

The accomplishments of NASA in the past year have dazzled the imagination and have instilled great pride in the American people. In a day and age when people are critical of Government programs and opposed to Federal spending, the public's support for civilian space activities has in no way been diminished. A 1984 Cambridge Report Survey indicates that:

Sixty-seven percent of the American public supports the U.S. Space Program;

Seventy-two percent of the American public thinks the U.S. Space Program should be continued;

Fifty-eight percent of the American public feels the space program should be expanded, and

Fifty-eight percent of the American public—after being informed of reasons for conducting it—support a space station program.

Mr. Chairman, it's hard to argue with results, and the can do agency has performed well. NASA and its employees have much to be proud of.

Senator **Gorton**. Senator Ford is here also.

Senator **Ford**. Let us get that in the record.

Senator **Gorton**. We will be pleased to hear any comments, Senator Ford.

Senator **Ford**. No, thank you, Mr. Chairman. I just came in to visit and listen. I have no opening statement.

Senator **Gorton**. Mr. Beggs, I think you will be first. You may proceed. We are delighted to have you with us.

STATEMENT OF HON. JAMES M. BEGGS, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY TOM NEWMAN, COMPTROLLER

Mr. BEGGS. Thank you, Mr. Chairman, members of the subcommittee. It is a pleasure for me to appear before the subcommittee to present President Reagan's budget request for NASA for 1986.

The total NASA request is $7.9 billion, of which $2.9 billion is for research and development, including $354 million for aeronautic research and technology, $3.5 billion for space flight control and data communications, $149 million for the construction of facilities, and $1.3 billion for research and program management.

The NASA budget for fiscal year 1986 provides for solid progress towards the aeronautics and space objectives approved by the Administration and the Congress. Consistent with last year's congressional endorsement of the President's space station initiative, our planning in fiscal year 1986 will proceed, but at a slightly slower pace than we had anticipated last year.

Our planning efforts will focus upon space station system definition and technology development, and will incorporate examination of both a manned-tended approach and advanced automation and robotics technologies. We hope to conclude agreements with ESA, the European Space Agency, Canada, and Japan in the near future to allow for parallel definition effort leading to significant international participation during the development phase. With the space shuttle, an increasingly mature system, a permanently manned space station is the next logical step in space for this Nation to take. We look forward to beginning its detailed design and development in fiscal year 1987 directed toward building this station within a decade.

The Space Transportation System built around the space shuttle will continue to gain operational maturity and demonstrate new capabilities. In fiscal year 1986, we plan 14 launches carrying commercial payloads, national security missions, and NASA missions to earth orbit and to planets. The Centaur stage will be launched on the shuttle for the first time. The first shuttle flight will be launched from Vandenburg Air Force Base. We will begin development of an orbital maneuvering vehicle to provide a new capability for orbit operations.

Space Science and Applications will experience a banner year. Early in 1986 a special set of three telescopes known as the ASTRO payload will fly aboard the shuttle to make observations of Halley's Comet. In early 1986, the Voyager spacecraft will encounter the planet Uranus and give us the first close-up look at that large, unusual, and unexplored planet, and then continue on its way to Neptune. The Galileo mission will be launched in late spring of 1986. An option has been added to allow the Galileo spacecraft while en route to Jupiter to fly by and observe the asteroid, Amphitrite. The Galileo orbiter probe will encounter Jupiter in December 1988, where the probe will be released into the dense atmosphere of that planet while the orbiter spacecraft remains in orbit to obtain additional data on the planet and take a close look at its satellites.

During that same planetary launch window, the Ulysses spacecraft, formerly known as the International Polar Mission, will be launched toward Jupiter and will use the tremendous gravitational force of that planet to accelerate into a trajectory that will permit inspection of the sun at high latitudes, that is, high sun latitudes never before available for observation.

Later in 1986, the Hubble Space Telescope will be launched into earth orbit to provide resolution far superior to that available in even the best ground based telescopes and provide a quantum jump in our ability to observe and understand the universe.

In addition, we will continue working aggressively on future missions, including the Gamma Ray Observatory, the Venus Radar Mapper Mission, the Mars Observer, and the Upper Atmosphere Research Satellite.

Consistent with the congressional action in the fiscal year 1985 budget, we will be pursuing development of the Advanced Communications Technology Satellite planned for launch in 1989 to demonstrate the technology needed for the United States to remain competitive in this important area.

Although fiscal year 1986 will be a vigorous year for the Space Science and Applications Program, it has been necessary to defer initiation of new projects which of course will be essential to the future vitality of the space science and applications area. I believe the hiatus in fiscal year 1986 is reasonable provided we make appropriate provision for new initiatives in future years.

In late 1984, NASA established the Office of Commercial Programs pursuant to the Administration's National Commercial Space Policy. This office will provide a focus to encourage commercial use of space. The fiscal year 1986 budget will continue and expand initiatives which began in fiscal year 1985 to stimulate research and development by aerospace and nonaerospace companies, facilitate access by private and academic entities to NASA facilities and equipment, establish new links with the private sector, and establish centers to promote the commercial development of space.

In Aeronautics, the fiscal year 1986 budget focuses on research and technology activities which supply and replenish the reservoir of technology that has been the fundamental source of our Nation's preeminence in aviation. In addition to the more general and generic technology, the budget continues a carefully selected group of systems technology efforts, including the numerical aerodynamic simulation project designed to move the United States to the forefront in the extremely complex area of computational fluid dynamics. We will also be working on the Advanced Turboprop Propulsion System to provide technology for a new generation of fuel efficient transport aircraft. The budget provides for modest growth in Space Research and Technology activities which are also crucial to the future U.S. leadership in space.

It also provides for establishment of the first of the fully operational three spacecraft Tracking and Data Relay Satellite System. We are launching the second of those satellites, I hope, very soon, with this next flight.

Mr. Chairman, I am satisfied that the budget we are requesting for fiscal year 1986 is a reasonable budget considering the constrained fiscal environment in which all programs must be considered. I am satisfied that we can and will achieve substantial progress toward all the Nation's major objectives for which NASA is responsible.

That concludes my prepared statement, Mr. Chairman. I would be pleased to respond to questions.

Senator GORTON. Thank you. Your entire written statement will be included in the record as if read.

Mr. Beggs, you have made a lot of news in the last few days with respect to the Air Force and NOAA's use of Titan II missiles in some of their missions. I should like to ask you to explain your position and your relationship with those two agencies in that respect.

And I gather it is the position both of the Air Force and of NOAA that it will be less expensive for them to utilize those Titan II missiles even after having them appropriately refurbished than it will be to pay NASA's charges for the shuttle.

I also understand it is your position that at least from the point of view of the country as a whole it is more efficient and less expensive to use the shuttle. This is an open-ended question. I want your comments from both sides of that equation.

Mr. BEGGS. I will try, Mr. Chairman. The problem with trying to get a handle on this issue that the economics of it are fairly complex, and I might say with respect to that article in the Washington Post of yesterday, that is sort of old news. That was kind of 2 weeks stale when it was printed with the comments I made. They were made something like 2 weeks ago.

Senator GORTON. It is nonetheless relevant.

Mr. BEGGS. It is relevant, but if the article had been updated, it would have read a little differently today than it did. The NASA position with respect to shuttle and shuttle cost is based on the assumption that we are going to continue to fly the shuttle some number of flights a year, regardless of what happens in the rest of the market.

It is my assumption that the United States has made a commitment both from the point of view of national and world leadership in space as well as the need to launch various payloads which only the shuttle can launch, and to do the other functions which the shuttle does uniquely, such as retrieval, repair, and the very special science that we can do with things like spacelab. If you assume that, then the fixed cost of operation will be incurred regardless of the flight rate, and the basic economics of the system are that the fixed costs of operation are by far the large major portion of the cost or the largest portion of the total cost of operation in any given year.

That includes, of course, the need to maintain a launch crew that will be there no matter what the launch rate, and the need to augment that crew is very minimal whether you launch 5 times a year or 15 times a year. It also includes the various facilities that we have both at Kennedy and at Vandenberg which are set up for a fairly high launch rate, and so you incur those costs whether you launch at a low rate or a high rate.

That means necessarily that the cost of launching one additional shuttle after you have assumed the launch of, say, five or six is on the order of $35 to $40 million, maybe a tad more in the time period we are discussing here; that is, from now until the end of the decade. And, therefore, we can launch the shuttle with payloads relatively speaking cheaper than almost any other means that are available, ELV's or anything else, again, assuming you are going to fly at all. So we have taken the position that the cheapest way of operating for launching payloads like NOAA requires, Metsats and Landsats and so forth. The cheapest way for launching military payloads is to fly on the shuttle. This has been an ongoing discussion, if you will, between ourselves, the military, NOAA, and our other customers for quite some time.

In this budget, it was announced by NOAA that they would launch the three Metsats which are beyond the current series on Titan II. We objected to that; we objected on two grounds. First of all, we did not think it represented the savings that were projected in there, and secondly, we have a long-standing agreement with NOAA that NASA is responsible for the procurement of the meteorological satellites, which we will do in this case as well, and as a consequence of that responsibility we are also responsible for determining the configuration of those satellites as to the launch system that we use for putting them in orbit Therefore, we are insisting, and still at issue between us, that those satellites will be configured for the shuttle, and will be launched on the shuttle and not on Titan II.

With respect to the military missions, there are undoubtedly some number of the military requirements where they fly in two unique orbits, or where they have a number of smaller satellites which they need to launch one at a time, which probably are fit payloads for Titan II's if they wish to develop and refurbish the Titan II. However, we are still saying to the Department of Defense the primary means, as spelled out in the President's space policy for launch, will be the shuttle, and that all of the other potential systems that are being discussed such as an ELV for backup with the large payloads and the Titan II and anything else are secondary to the shuttle. The major portions of the military's payloads, their manifests will be flown on the shuttle.

Senator GORTON. I wanted to ask more questions on this subject, but I will interrupt and defer to Senator Hollings at this point.

Senator HOLLINGS. Mr. Chairman, you are very kind and I appreciate it. This morning we have our distinguished former ranking member, the Senator from Alabama, Senator Heflin, who over the years has been leading the effort here within the Subcommittee for Science, Technology, and Space, He is going to be leaving in the readjustment of the rules and regulations that we have with respect to committee assignments and we are going to miss him very sorely.

At the same time I want to welcome the distinguished Senator from Tennesse, Senator Gore, who has already got an established track record in Science and Technology over on the House side. We are very fortunate to have Senator Gore, but more particularly, I wondered if the distinguished chairman would yield to Senator Heflin and let him have his last few words on the Marshall Space Center before I move it to Columbia, SC.

Senator GORTON. The Chairman would be delighted to yield to Senator Heflin, but only after he has told everyone how much he is going to miss his ranking minority member from the last Congress as well. I have not only enjoyed the company of Senator Heflin on this subcomittee, but I have also gained a great deal of insight and knowledge into the space program, and all of the rest of the programs over which the subcommittee has jurisdiction, and he will leave a real gap in the subcommittee.

I, too, want to welcome to both the Commerce Committee and to the Space Subcommittee the new Senator from Tennessee, Senator Gore. He obviously will be a great contributor. But at this point I would yield to Senator Heflin, with great regret, because I wish you well, sir, here in the same position.

Senator Heflin. Thank you. I have great regret myself that I am leaving, but from my great and diligent study on this committee, I understand certain atmospheric conditions that exist in Charleston, SC, will prevent the move of the Marshall Space Center to that city.

Mr. Chairman, last week I made the difficult decision to give up my seat on the Commerce, Science, and Transportation Committee in keeping with new rules that limit a Senator to two major committees, sometimes referred to as "A" committee assignments.

I have certainly enjoyed my service on the committee, particularly my work with the Science, Technology, and Space Subcommittee, and it is with great reluctance that I had to make that decision. While I will greatly miss my role as ranking member of the Science, Technology, and Space Subcommittee, I will nonetheless continue to concentrate my attention and energies on the programs within its jurisdiction.

I look forward to a continuing relationship with the chairman of the subcommittee, Senator Gorton, and his staff as well as the staff of the minority, and I want to thank my distinguished colleague, Senator Gorton, for his cooperation, for the excellent job that he has done as chairman of this subcommittee.

I have been fully supported by Senator Hollings as the ranking Democrat on the overall committee, and I want to thank him for all of his courtesies and help, too, relative to my participation in the overall Commerce Committee's activities, as well as in the subcommittee.

Mr. Chairman, I appreciate this opportunity to say a few parting words about the proposed NASA budget for 1986. Any NASA authorization bill should be founded on four basic principal objectives.

First, provide the necessary support to ensure the technological leadership of the United States in space. Second, send a signal to the private sector that the Federal Government is committed to the commercialization of space. Third, indicate a strong commitment to and support of space science and space application programs. And fourth, continue to lay a firm foundation for the next logical step in space, a permanently manned space station.

In my opinion, the fiscal year 1986 NASA budget accomplishes these objectives by blending strong support for ongoing activities with funding for important new initiatives such as the advanced x-ray astrophysics facility. I believe the maintenance of the level of NASA funding to include inflation plus 1 percent is reasonable and permits modest growth to specific space activities.

Generally, the fiscal year 1986 budget provides NASA an exciting challenge with the many space activities and the potential of expanded commercial space participation. In regard to the space station, I believe the proposed funding level for the space station is adequate to carry out the 1986 activities.

As I have stated before, the space station represents a bold step into the future at a time when the degree of international and private sector interest in space is at a peak, as is the degree of competition to the U.S. Space Program from the international and the private sector.

The space station is a bold step toward the conduct of low Earth orbit and the development of a space infrastructure which represents a major evolutionary step in man's experimentation, use, and conquest of space. It is also the type of action required if the Nation is to maintain its leadership role in space, a role that could easily be lost if the United States fails to proceed with the development of the permanently manned space station.

Next, on space commercialization, during the spring of 1983 I held hearings in Birmingham and in Huntsville, AL, on the potential of the commercial uses of space, especially material processing, and from these hearings it is evident that there is a great interest and anticipation on the part of private enterprise and academia in the future of commercial activities in space.

The present material processing activities by the 3M Corp. and the planned University of Alabama protein crystal experiment are two examples of the activities in this area. Yesterday there was a news release from UPI that I have quoting from Aviation Week and Space Technology, an aerospace news magazine, which says that "Space shuttle experiments scheduled for flight in early March and August will pave the way for a breakthrough in the development of new drugs to fight cancer and other ailments."

This to me is a significant effort in regard to experimentation at microgravity. I think it will be very helpful and I think that it will help us move forward to find the cure for a great number of diseases, and hopefully cancer will be one of those for which we will find a cure. I also believe that these activities and scientific experimentation in space can do a lot in that regard.

For future applications to continue to evolve, it will be necessary to adequately fund and provide for growth of current commercial activities, to provide for an initial occupancy of the space station by a set of commercial users. Significant progress in the area of materials processings has been made with recent shuttle flights.

These activities are moving at an accelerated rate, and the funding associated with these is supporting that rate. However, additional funding may be necessary in the future if we are to meet the potential expected for the space station's initial operating capability in the early 1990's.

Foreign participation, much has been said recently about the potential participation by the Europeans, the Japanese, and the Canadians in the space station program. Much of the discussion involves the building by the Europeans and the Japanese of a manned laboratory for the investigation of commercial material processing type experiments. This expressed interest certainly supports my belief that the space station will have substantial commercial benefit to mankind.

However, on the downside, there is also the potential for usurping our Nation's lead in technology and subsequent advantage in the world marketplace by foreign participation and by these foreign activities. We must ensure that the space station program is directed such that foreign participation can be maximized with minimum transfer of technology from this Nation to foreign marketplaces.

Also, I would hope that our program planning will not be impacted if the foreign participants were to develop independently a manned module for utilization as a laboratory and attached directly to the space station.

Orbital maneuvering vehicle, I am pleased to see that the orbital maneuvering vehicle is an agency new start for fiscal year 1986. This versatile orbital system, much like a harbor tug, would greatly expand the operational capability of the shuttle. The OMV will be used to deliver or retrieve satellites from orbital attitudes not achievable by the shuttle.

It is also planned that additional capabilities will be added to it which will permit it to accomplish on-orbit servicing and inspection of satellite systems deployed in orbits not attainable by the shuttle.

This additional capability will afford a service not only to the NASA missions but also to the commercial sector, and can ultimately reduce costs and provide added operational time for commercial assets in space.

Large lift capability, one area of controversy which may be much discussed this year is the building of a large lift capability vehicle. In the future NASA will need such a capability to support the planned commercialization of space, as well as our defense needs.

I believe that the Air Force and NASA should evolve together a common approach to the solution of the Nation's launch vehicle need as was accomplished by the development of the shuttle.

Also, NASA should assume some paramount responsibility for the management and the development of the systems as they may utilize the shuttle elements.

Finally, Mr. Chairman, I wish to commend Administrator Beggs and his staff for proposing a budget that prudently balances the diverse needs and the requirements of the Nation's civilian space program. I look forward to working closely with the subcommittee in fashioning from the budget proposal the 1986 NASA authorization bill.

I would also like to commend Administrator Beggs for his foresight and his moving forward in the space area, and the staff of NASA as well as the staff of this committee, both the majority and the minority staff.

It has been a pleasure to have participated in the activities of this committee, not only as it applies to space, but as to developing technologies. The roles that universities, industry, and the government can play in developing technologies is a most interesting undertaking and is something that we should thoroughly explore.

It has been a great pleasure to have served on this committee, and I look forward to coming back, being a witness, and being an observer of the activities of this committee in the future. Thank you very much.

Senator GORTON. Thank you very much, Senator Heflin. As I have said, we will really miss you, and we will ask for your contribution and your thoughts on these subjects frequently.

Senator Ford?

Senator FORD. Thank you, Mr. Chairman. Lincoln said after he had successfully defended the railroad against the ferry operators across the Missouri River, "When progress is made, someone gets hurt." Now, some feel that the change in the assignment on committees and the number each should have is progress.

Well, in that so-called progress I think this committee gets hurt by the loss of our good friend, Senator Heflin from Alabama. And I think the statement that he just read indicated his special interest in and his unique quality to help all of us make some tough decisions as it relates to not only the future of this country, but of the world.

And so as he departs, I thank him for his many contributions and ask that he continue his interest in what we do here. Even though your position will be difficult to fill, I am very pleased that one who is so well qualified is joining the committee, Senator Albert Gore from Tennessee, and I look forward to working with him, Mr. Chairman, and thank you for the opportunity to make these remarks.

Senator GORTON. Senator Gore, I believe this is the first opportunity you have had to attend either the full committee or subcommittee. You did not have an opportunity to make an opening statement, and I would be delighted to give you that opportunity now.

Mr. GORE. I appreciate it, Mr. Chairman. I look forward to serving on the subcommittee.

As chairman of the House Science Investigation Subcommittee for the last several years I have been active and interested in virtually all of the issues that fall within the jurisdiction of this subcommittee, and I am very excited about the chance to work with you.

The only thing I would say by way of an opening statement is that I hope the ranking minority member of the full committee realizes that there are many, many Tennesseans who work at the Huntsville Space Flight Center, and I certainly anticipate taking up where the Senator from Alabama has left off in making certain that there is a rational development of the space program. I just wanted to lay that out.

Thank you, Mr. Chairman.

Senator HOLLINGS. Mr. Chairman, thank you very, very much for your courtesy. We are going to miss Senator Heflin. But I am confident you will invite him from time to time to sit with the committee.

Senator GORTON. Thank you.

Mr. Beggs, to get back to the subject both of the Air Force and of NOAA, do you have the flexibility at the present time in NASA to continue negotiations with either NOAA or the Air Force in such fashion that you can prove to them that it is not only better for NASA that they continue their present relationship, but it would be to the advantage of those two agencies as well from the point of view of their own fiscal discipline?

Mr. BEGGS. Yes, sir. I believe we do. We are continuing to discuss with both the Air Force and NOAA. As a matter of fact, as recently as last week, I had some discussions with the Under Secretary of the Air Force which led to an agreement, I think, which has now been put into force by the President, that resolves some of the issues between us with respect to the heavier lift ELV's, so that, I think, is behind us. We will continue to work with NOAA to resolve those issues.

Senator GORTON. Are you going to ask us for any specific legislation in this authorization bill, in this report, or in the NOAA authorization bill which will facilitate your efforts in that regard?

Mr. BEGGS. No, sir; I do not think it is necessary. I think we can work this out.

Senator GORTON. Have these concerns had anything to do with NASA's present decision not to purchase a fifth orbiter?

Mr. BEGGS. Well, I would not be completely candid if I say it had no impact on that, but I do not think it was a major factor in the fifth orbiter decision. Several things have happened in the last few years that have impacted the projected shuttle manifest, not the least of which is a decline in the projected demand for communications satellite services. We had anticipated that the demand would continue to grow, and in the near term it has not. In the long term, perhaps it will, but the projected demand of the commercial satellite market, the military requirement for flights, and the other U.S. Government and foreign demand is just not sufficient to justify flight rates beyond the 24 a year that we are now projecting in the outyears.

Therefore, we are saying we do not need the fifth orbiter to meet that kind of demand. If it were to develop in the nineties that the demand would start increasing, then I think we would probably be better advised to proceed with the second generation shuttle system to satisfy that demand. Then, we would need to buy a fifth orbiter at this time in anticipation of increased demand.

Senator GORTON. Let me go on to the space station, and I would like you to describe the effects of the reduction of the $280 million originally requested by NASA and the $230 million included in the budget submissions of the Congress on the scope, schedule, and risks of the program.

Mr. BEGGS. Mr. Chairman, we, of course, had configured that funding profile so as to try to achieve a 1992 IOC, giving ourselves 2 or 3 years' grace in the commitment we had made to the President that we would have it operational within a decade.

With the budgets and the budget runouts we are projecting now, we are cutting into that period at the time of initial operating capability, because it does not end at that point, by maybe 1 year or 1½ years 15 months, would be a good estimate, I think, at this time.

Now, we do intend to continue on schedule to let our phase B studies with the industry on April 1 of this year, and we will proceed with those phase B studies to the point where we can move to the phase C and D effort in fiscal year 1987, but we will proceed at that point at a slower pace in the development and fabrication activities, and probably look at an IOC in 1993 or perhaps even early 1994.

Senator GORTON. Does that slowdown significantly threaten to increase the original $8 billion cost estimate for the space station?

Mr. BEGGS. We still feel we are within the $8 billion estimate, which as you know was built on a constant dollar estimate. Adding a year or two at the end, we will incur that much more escalation in the cost, in that $8 billion.

Senator GORTON. But only inflation.

Mr. BEGGS. Only inflation; yes, sir. But I think we still feel we are reasonably comfortable with that figure, although we will know more, and of course we will report as we get into and toward the end of our phase B study. That will give us greater insight into the costs.

I might say that the response of the Europeans and Japanese has been very gratifying in this regard. They appear to be stepping up to spending at least the kinds of resources that we had asked them to spend, in fact maybe a tad more. The Europeans in their recent executive conference in Rome did vote to proceed with the phase B studies, and projected an investment of upward of $2 billion, and the Japanese are in turn looking at an investment of about $1 billion in the station. So we are very gratified with the overall progress to date.

Senator GORTON. When do you expect a phase B memorandum of understanding to be signed with ESA, the Japanese, and the Canadians, and what issues are still unresolved?

Mr. BEGGS. The Japanese MOU, I think, is pretty much resolved. There may be a few more details to work out, but I think that will be the first of the MOU's to be signed, and it may be signed within the next week or two, certainly some time in March. So we ought to be in good shape to proceed with the Japanese on the same time schedule as we have with our own industry.

Senator GORTON. Will they be able to finish within the 21-month schedule?

Mr. BEGGS. I think in the case of the Japanese the answer is that it is very likely that they will. The European schedules, while they have still yet to be worked out, that is, the agreement has yet to be worked out completely. We are still discussing certain aspects of technology transfer which, as everyone anticipated, would be a difficult issue to work out because of the necessary safeguards needed both from their side and from our side.

It is as large an issue for the Europeans as it is for us. So, we have to ensure that the language we draw is adequate to overcome any problems that we encounter. At the same time, we cannot get ourselves into such a strict and rigorous system that we cannot exchange information. We have got to exchange technical information if we are going to do this job together. I think we will work that out, but it still remains an issue between us, and the details of it, I think, will be resolved by the end of March or early in April. So they, too, will come along at about the same time period.

They are still, I think, pointing to the schedule as being very tight for them, but I think as they always do once they get in it, they will start to move.

Senator GORTON. In November, the OTA space station report suggested that the private sector rather than NASA should develop more of the mundane elements of the space station while NASA should pursue more of the cutting edge technologies.

Could you comment on that OTA recommendation and the considerations which NASA itself took into account in deciding on its mix of off-the-shelf technologies with cutting edge technologies?

Mr. BEGGS. I think if we get proposals from the private sector to contribute elements to the space station, we will take them up on it. We will buy off on whatever they propose to us as items they would like to contribute. We have targeted our technology money at the cutting edge technologies that we think are going to be necessary to make the space station truly a very efficient and highly capable facility, things like the life support systems, where we hope to for the first time perhaps partially close those systems so as to reuse the consumables that we take up that will increase its efficiency quite a lot, robotics, and the automation techniques that will make the station much more efficient. If you think about the problem we are confronted with, the initial crew of the station we envision to be perhaps six or eight or maybe one or two more, but that means since we will want to work around the clock, the average crew size will be two, or maybe three, we are going to want a lot of automation and a lot of robotic assist to help us.

We will want to marry with the station the orbital maneuvering vehicle that we have in this year's budget which will enable us go to retrieve satellites that will use the capability that we expect to build into the station to repair and refurbish satellites on orbit. That is a very important function.

We are going to have to look to the various pieces and parts we will need to allow the astronauts to operate both outside the shuttle and perhaps away from the shuttle, because we do plan to have platforms for scientific instruments associated with it. We will want our astronauts to go visit those platforms from time to time, replacing instruments or perhaps on repair missions.

So, there are a number of very important cutting edge technologies, and I am sure Mr. Culbertson is prepared to discuss in quite some detail the fairly lengthy list of them that we think the money that we are spending can be very profitably employed.

If we can get proposals from the private sector to come in and pick up on the more routine aspects, we will certainly take them up on it.

Senator GORTON. Senator Hollings?

Senator HOLLINGS. Thank you very much, Mr. Chairman.

Mr. Beggs, we wonder in budget freeze proposals if we really save money, or in reality do we waste money? To get right to your particular budget, you are asking for an increase of around $360 million almost $400 million. Last week, the Office of Management and Budget in a budget reduction paper proposed a cut from the fiscal year 1986 NASA budget request of about $360 to $380 million. Does this budget reduction option of OMB just eliminate the increase in the fiscal year 1986 proposal? Am I accurate?

Mr. BEGGS. Well, so far as I know——

Senator HOLLINGS. Excuse me. That was the Congressional Budget Office, not the Office of Management and Budget. I am sorry, I misled you.

Mr. BEGGS. Yes, I read that report, Senator Hollings, and as I understand it, the CBO recommendation breaks down into two parts, one of which is a proposal that is similar to the one that OMB proposed, and that is a reduction in civil aeronautics of about $160 million or thereabouts, $140 to $160 million.

We have argued this issue over the years many, many times as to the value and the importance of that civil aeronautics program. It is not something that you can turn off and on, and the reason for that is very obvious. We have people and facilities engaged in that, and if you stop it, the people disappear and the facilities are shutdown. It means that if you ever want to go back and do it again, you have to start them up again, and that is both expensive and difficult. In addition to that, if you stop your aeronautical research for a period of time, you will put a gap in the flow of technology into the field. Aeronautics is both an art and a science which requires a continual refreshing of the reservoir of technology that you use in order to enable the industry and our aeronautical design activities to design the advanced aircraft that we need in order to maintain our lead in the world.

Furthermore, it is very hard to separate civil aeronautics technology from military aeronautics technology. I will give you one example, one personal example. In my career I have been in the aerospace industry all my business life. We were modifying an airplane, putting a new wing on it. That was the F-16. We reached into the book that provided various air foils to us which comes out of NASA, and found one that looked like it would be a very good adaptation of the F-16 and would make it fly faster and longer range and make it a much better aircraft in general as a fighting machine. That wing, which was put on the aircraft that is now flying, was originally designed for the supersonic transport. However, it found its first application on a fighter plane. There are examples like that all through the technology where techniques developed for military aircraft flow into the civil field and vice versa.

So they are very hard to separate, and if you stop one, you will no doubt suffer in the other. Therefore, we have in every case come to the conclusion that it would be "penny wise and pound foolish," if I may use that old expression, to stop your civil aeronautical research and technology even for a short period.

Senator HOLLINGS. Well, that is the point. I am trying to determine in a budget freeze proposal where am I being "penny wise and pound foolish" to extend the 1985 budget level for the year 1986?

Mr. BEGGS. Yes, sir, and the other part of the CBO's recommendation goes to the shuttle flight rate. It is proposed that we could cut back by eliminating a certain number of flights each year. Well, I touched on that in answer to the chairman's question earlier. If you cut the flight rate, it is not going to reduce the better than half the cost that you incur just to keep the system flying, the fixed costs that are associated with it. Furthermore, you would have to take out of the flight manifest those flights which are primarily either NASA flights or Government flights. If you eliminated commercial flights, it would cost more rather than less, because we get a positive contribution from those commercial flights to the overall fixed cost of flying the shuttle.

Now, if you take four or five shuttle flights out, you can save some money in any given year, but the remaining flights, as I say, will cost you more per flight. The savings per flight work out to be

$40 to $50 million, if you start early enough to modify your production schedules for the things like the external tank, the solid rocket booster, and so forth, the consumables, so as to reduce the quantity of equipment they are producing.

If you do not get those stops, and the lead time on those, I should say, is probably about 30 to 35 months, so you have to start fairly early if you are going to modify those production schedules, but you can save in some given year, any given year, that much money per flight, which will again drive up the cost per flight in that year.

Senator HOLLINGS. I will get my staff to work with your staff to try to separate out; if it is possible and practicable; those items in the fiscal year 1986 budget request scheduled for an increase that would be those penny wise and pound foolish to freeze. Programs like the military's budget for building another aircraft carrier. Programs that you do not just stop construction on for 1 year.

And in a similar vein those programs that if you do hold them up, you eventually come right along and spend even more money, wasting a good bit. If there is some way to separate out these items and programs, and I do not want to take the committee's time, but I do want our committee staff to see if they cannot work and find out what items they should continue in an economic sense and which ones would be just purely judgmental as to whether we stop them now or add them on as a new venture.

Thank you, Mr. Chairman.

Mr. BEGGS. If I may, Senator, I would like to add this one remark to the aeronautics remarks I made. Dr. Keyworth in 1982 conducted a study on aeronautical policy, and when he sent his recommendations to the President, he made the following statement, and I think this is a very succinct judgment of the issue.

> We found that a continuing strong Government program of aeronautical R&T is vital to our future national security in civil market competitiveness, and satisfies the administration's twin criteria of excellence and relevance.

I might add to that that the positive balance of trade that we have achieved in this country through the sale of aeronautical and aerospace products around the world is second only to agriculture.

Senator HOLLINGS. About how much? What dollar amount?

Mr. BEGGS. Well, it was $10 billion in 1984. That is the most recent year, but I can supply you with the various figures. It has been very strong for the last 15 or 20 years.

Senator HOLLINGS. Thank you very much.

Thank you, Mr. Chairman.

Senator GORTON. Senator Gore.

Senator GORE. Thank you very much, Mr. Chairman.

Mr. Beggs, before asking some questions I would like to request that the additional budget justification documentation be supplied for the following accounts: Office of Commercial Space Programs, Orbital Maneuvering Vehicle and Shuttle Production and Operating Capability. These two new starts and one major reduction I think deserve a more thorough justification. I know that OMB likes to limit the amount of paperwork, but do you believe you could supply that for us?

Mr. BEGGS. Certainly.

[The following information was subsequently received for the record:]

The FY 1986 funding request of NASA's Office of Commercial Programs will build upon the commercial use of space activities initiated in FY 1985. In seeking a greater private sector commitment of resources to commercial space research and development, NASA's FY 1986 commercial program budget request will support the commercial development of space in the following areas:

Centers for The Commercial Development of Space (CCDS): NASA will continue funding of CCDS research centers to accelerate the process of moving ideas developed through basic research into the commercial space marketplace. As in FY 1985, NASA will furnish funding for three to six centers at an annual funding rate between $500,000 and $1 million per center.

Stimulating NASA Research with Commercial Potential: NASA can facilitate the commitment of private resources to commercial space endeavors by enabling industry to have an input in setting NASA's research agenda, and by conducting research with commercial space applications. In FY 1986, NASA will use mechanisms such as the NASA Advisory Council to assure that NASA R&D is responsive to the trend toward the commercial use of space, and fund commercial space research projects sponsored by NASA field centers.

Stimulating Private Sector Commercial Research: NASA funding of private sector commercial space research will help to reduce the up-front risks and costs of basic research that will support commercial space endeavors. The NASA Small Business Innovation Research Program is one mechanism that will be used to stimulate private sector commercial research.

Increasing the Availability of NASA Facilities and Equipment: In FY 1986, NASA will continue to enable industry and university researchers to consider space flight experimentation without major investments in highly specialized equipment. NASA seeks to expand the availability of facilities such as furnaces, optical fiber production devices, and protein crystal growth devices.

Outreach: NASA will seek to enhance NASA's links with industry, universities, and the financial and insurance communities through mechanisms such as researcher exchange programs and seminars.

Additional budget justification on reductions in Shuttle Production and Operating Capability.

The FY 1986 Budget request reflects a reduction of $515M from the FY 1985 requirement. These reductions are the result of the completion of several specific content items. Details by major budget element are as follows:

ORBITER	FY 1985	$655M
	FY 1986	$334M
	REDUCTION	$321M

The major reasons for the reductions are: Orbiter 104 is being completed and delivered to KSC in April 1985, Orbiter 102 modification will be completed and the vehicle delivered to KSC in July, This will complete the manufacturing effort at Rockwell for the four orbiters; the initial lay-in of orbiter spares to support operations will be completed by the end of this year, although the procurement of rate spares will continue, this is at a lower level; with the completion of early flight analysis this year, the continuing engineering integration effort to support operational flights will be covered entirely in the Shuttle Operations budget; and, the engineering effort required to support the incorporation of STS Centaur and Filament Wound Case into the Shuttle system are nearing completion, only minor analysis effort will be required in FY 1986.

PROPULSION SYSTEM	FY 1985	$582M
	FY 1986	$454M
	REDUCTION	$128M

The major reasons for reductions are: production of complete main engines will slow in FY 1986 following delivery of the engines to outfit the last of the four orbiters by summer; Filament Wound Case development and delivery of the flight unit for the first flight will be delivered to VAFB in FY 1985; and the basic rate tooling to provide a Solid Rocket Booster production capability of 24 flights per year will be essentially completed in 1985.

LAUNCH & MISSION SUPPORT	FY 1985	$230M
	FY 1986	$164M
	REDUCTION	$66M

The major reasons for reductions are: completion of major second line facilities at KSC (e.g., Pad B), and the modifications required to accommodate STS Centaur will be completed by the end of 1985 in order to support the Galileo and Ulysses planetary mission in May 1986; the upgrade of the Mission Control Center to support 24 flights per year will be completed in 1985; and production of space suits will be reduced in 1986 from the 1985 rate.

The estimated cost for the Orbital Maneuvering Vehicle (OMV), Design, Development, Test and Evaluation (DDT&E) and first flight unit is $375-450 million. The procurement effort would follow completion of current definition efforts and start this fall. The first flight is planned for early 1990.

The OMV is a reusable, remotely piloted vehicle that increases the "reach" of the STS by moving payloads to and from the STS. It moves these payloads under ground control, freeing the Shuttle crew to perform other operations during payload transportation to/from the STS. It eliminates the need for STS energy and crew time in making these local stops. The OMV can, for reference, move a 5,000 lbs. satellite in a roundtrip orbit altitude change of about 1200 nmi. or effect about a 7 degree orbit plane change, so it has quite a large orbital maneuvering capability.

The primary use of the OMV will be in bringing satellites to the Shjuttle (or later Space Station) either for servicing by the crew or return to Earth. In particular, the OMV is expected to play major roles in the Hubble Space Telescope (HST), Advance X-Ray Facility (AXAF); future Earth observation, communications, and science spacecraft. Our recent success is saving three satellites, along with the logically expected increase in these mission operations that success brings, strongly supports a need for additional capability to bring and return future servicing "customers" to the STS. This is particularly true in polar orbit operations, where we will soon be operating through Shuttle launches from its Western Test Range (WTR). The Shuttle has much less payload capability from the WTR in polar orbit, since the rotation velocity of the Earth (available in the ETR equatorial orbit launches) is not available. The OMV will efficiently increase the orbit payload delivery/retrieval capabilities of the STS polar orbits.

The OMV also permits future launch of payloads from the STS without thier own propulsion/fuel systems, thus reducing satellite cost. Some payloads, such as our potentially promising commercial materials processing application, do not want integral fuel tanks due to "slosh" perturbation; yet want periodic removal of products and resupply of materials. The OMV will perform these operations from the STS beginning in 1990 and be fully checked out to serve a possible role with the STS in assembly of the Space Station. We envision a need for a second OMV to then be stationed at the Space Station for maneuvering operations, along with the original STS-based OMV which will handle orbits not accessible from the Station and its OMV.

Senator GORE. In addition, I would like to request a copy of the backup documentation used in the Landsat-IV repair-retrieval options feasibility report submitted to the Congress on February 7.

Mr. BEGGS. Yes, sir. We certainly will.

Senator GORE. Now, I would like to ask a few questions about space science and applications. Why are there no new starts for space science and applications in the fiscal year 1986 budget request?

Mr. BEGGS. We could not squeeze any in this year, Senator, with the budget we had, and—well, a couple of things happened to us. One was that the reimbursements for the shuttle operation, particularly for the military, the DOD, were down in fiscal year 1985, and we had to absorb something over $250 million of shortfall in those reimbursements. And that is just simply due to the way in which the military had scheduled its flights. We did not get as many flights in the current time period as they had projected. And, of course, we had included in our numbers in addition to that, we had programmed increases built into the Space Science and Applications Program of about 15 percent, and that budget is up from about $1.4 to about $1.6 billion.

This simply reflects the past new starts we have had in that program, plus the fact that some of those programs are reaching the point of their maximum expenditures. That will go down a tad next year, which will leave some room for some new starts next year.

Senator GORE. What new starts in space science and applications should we expect to receive next year?

Mr. BEGGS. Well, there are several candidates that fell out this year. One is the TOPEX experiment, the oceanography experiment, which the oceanographers have been very interested in for a long time. We would like to get that one started, and there is potential for international collaboration on that.

Another one that fell out was the Gravity Probe-B which is a very sophisticated experiment which will try to prove or disprove one aspect of Einstein's theory of relativity, which is of high interest to the physicists. But even more importantly than that, it leads to other things that make it desirable.

Another is the AXAF, which I think Senator Hollings touched on, or Senator Heflin touched on, which is the Advanted X-ray Astronomical Facility. We have a series of these more or less permanent—they are not really permanent, but they will be operational for a long time—astronomical observatories which cover the various parts of the spectrum. And the one that is next in line after the Gamma Ray Observatory is the X-ray Astronomical Facility. And there are a number of others.

Now, we will not have a great deal of room for many of those, but we will pick from that list depending upon which one looks to be highest on the priority list.

Senator GORE. Now, when you say there is potential for international cooperation in TOPEX, is it not a fact that the French have indicated they will go ahead without us if we do not participate this year?

Mr. BEGGS. Well, they may, they may, indeed.

Senator Gore. Well, that would not be a pleasant result for us, would it?

Mr. Beggs. Well, it is not something that would be a happy situation. However, it is not catastrophic in my view either. The program that they will probably run is not the same program that we would have run had we collaborated. But if they go without us, then we will have to, when we reinitiate our program, we will have to go it alone.

Senator Gore. And it will end up costing more money.

Mr. Beggs. It could.

Senator Gore. It probably will. I mean would you not say it probably will if we are going it alone?

Mr. Beggs. But the reason I would hedge just a bit on that is that until you actually sit down and put the program together, it is not at all clear as to whether doing it in a collaborative way costs significantly less money than going it alone. It really depends on how much equipment and how ambitious your program becomes. And I will repeat, it probably will cost more.

Senator Gore. So, we are not saving any money there. Is not a similar situation developing with the ISTP, where the Europeans have indicated this is the critical year for their decision to participate?

Mr. Beggs. No, sir; I do not believe so. I think that that one is different. The ISTP is a program which is really not one single set of objectives or even satellites. It is a whole series of activities which will go on for a long period of years. The cost of that program is quite significant. There is great interest in it, both in NASA and abroad. But, the earliest likely start would be the Japanese contribution to that. Theirs comes along the quickest, and I think we will be able to accommodate that. I think the Europeans are on a less rigorous schedule, and I think that if we were to get the initial parts of ISTP initiated in this year, too, we will probably be on a time schedule which will mesh very well with theirs.

Incidentally, the Soviets are interested in that program as well, and this could be a very, very large international collaboration once it gets started. Each of those parties would contribute a different piece to the program. It would not be a collaboration in the sense of our designing single satellites or single spacecraft, but each of them would probably develop a set of spacecraft on their own, and then we would tie them all together to study the solar terrestrial environment, which is a fascinating and vital subject.

Senator Gore. Let me shift gears now and ask you a few questions about the space station. Could you please give the committee the projected budget for the space station over the next 5 years?

Mr. Beggs. Yes, sir; it is in at $230 million in fiscal year 1986. Of course, the Congress authorized and appropriated $150 million last year, $580 million in 1987, $1,050,000,000 in 1988, $2,070,000,000 in 1989, $2,270,000,000 in 1990, $3,310,000,000 in 1991, and $1,533,000,000 in 1992, and then it runs out at 1993 at $208 million. But, I would like to add something there, if I may, Senator: that it does not really run out in 1993. It would get us to the initial operational capability, and then we would expect to continue to operate. It would be an operating budget as well as a continuing budget for upgrading and expanding the station.

Senator GORE. What are the estimates for the O&M costs for the station?

Mr. BEGGS. We really have not arrived at a hard figure for that, and we will do that in the upcoming phase B studies. That question, incidentally, is one that we get asked constantly by not only the industry folks that are interested in it, but also from our foreign collaborators who are very interested in what kind of costs they are likely to incur when they get out and want to use it.

If you want me to give a top-of-the-head guess, I would say it is in the several hundred million dollars a year category, perhaps a half a billion dollars a year for the basic operation.

Senator GORE. How much?

Mr. BEGGS. A half a billion dollars a year for the basic operation, but please do not take that as a hard figure, because we have yet to define it. The definition, of course, will include all of the various activities that we intend to put into the station when we reach that IOC date.

Senator GORE. Why is NASA so reluctant to establish a target date for the IOC?

Mr. BEGGS. Because we want to be very sure that when we give you that date that we are going to meet it. And we are, I guess, a little sensitive on schedule, since we suffered in our most recent program, the shuttle, a 3-year delay after we established an IOC date for shuttle. We will give you a hard date, though, as soon as we get through the bulk of the major part of our phase B studies. We will set a hard date, and we will set one we think we can meet.

Senator GORE. I am sympathetic with the problem, but it does complicate planning, program development and budget activities to some extent.

Mr. BEGGS. Well, the date that we have tentatively set as an operating date is 1993 right now. But, as I say, I really do not want to make that a hard date at the present time.

Senator GORE. All right. That is fine.

Now, could you give the committee your view of what components the IOC configuration will consist?

Mr. BEGGS. It will consist of the core facility which will include all of the utilities, the power, the various consumable items that we will utilize and supply to the various modules; probably, of course, a module where the astronauts will live while they are working in the station; at least one, and perhaps two, laboratory modules, places where experimentation and scientific work can begin; two platforms—well, I should say one or two platforms, but it looks like it more likely will be two—which will fly with the station; probably a logistics module to store the various pieces and parts that we will from time to time have to replace on orbit; and I think most likely a platform in polar orbit to allow us to do the Earth observation and the other observations that can best be done from polar orbit.

Senator GORE. So, a polar orbiter would be in the IOC?

Mr. BEGGS. Yes, sir; In addition to that, there will, of course, be required a docking module or a docking station to allow us to dock with our shuttle, as well as perhaps other kinds of vehicles that may be used for resupply. The Europeans, for example, have suggested they might be interested in developing a resupply vehicle of their own. Also, we will need a place exterior to the modules to work on satellites for purposes of repair and upgrade.

Senator GORE. Now, will any of the components you have just listed be supplied by our foreign partners?

Mr. BEGGS. Yes; I suspect that at least one of the laboratory modules will be, may be one of the platforms, potentially pieces and parts of some of the other modules that I described.

Senator GORE. All right. Now, recent testimony before the House Science and Technology Committee indicated it would take seven shuttle missions over a period of 9 to 12 months to achieve the IOC. Are the cost of these dedicated shuttle flights included in the cost estimates?

Mr. BEGGS. They are included in our budget runouts, but they are not included within the $8 billion.

Senator GORE. Are they included in the figures you just gave me?

Mr. BEGGS. No, sir.

Senator GORE. Will the foreign partners be required to use the shuttle as the primary transportation mode to the space station?

Mr. BEGGS. I think perforce they will, because at least for the initial period of years, because there will not be another vehicle available. But, if they come along with something like the French are talking about with a Hermes spacecraft, then that, too, could be used. But I think they will most likely use the shuttle, but it is not a hard requirement in our mind.

The shuttle is a very versatile machine and would permit revisiting the station after it has gone up for other missions. And, of course, we have a very heavy lift capability. In the 1990 time period we probably will have a payload capability in the shuttle of close to 70,000 pounds.

Senator GORE. For the record, if you could supply a justification for not including the dedicated shuttle flights in the cost estimates for the station—and I do not want to go into that with you here—but my own view is that a better way to do that is to tell us what it cost and include all the costs in it.

[The following information was subsequently received for the record:]

NASA typically does not include the cost of the STS in its cost estimates of payload development programs such as Spacelab, Hubble Space Telescope, and the Space Station. Since the definition stage of the Station is just beginning, we do not know enough at this time about the Station's ultimate configuration and assembly mode to determine exactly how many Shuttle flights will be required.

Senator GORE. Mr. Chairman, you tell me if I am going too long. I have a few other questions.

Senator Gorton. Go ahead.

Senator GORE. On shuttle pricing policy. Could you give your views on the pricing policy and the process being used to formulate the post-1988 options in pricing for the President?

Mr. BEGGS. Yes, sir; this is a subject that goes on and on, and you tell me when I am talking too long.

Senator GORE. Well, try to keep it within reasonable boundaries.

Mr. BEGGS. In the beginning back in 1975 to the 1977 time period, we established a flat price for the first 3 years of operation of $18 million per launch. These are all in—that one is in 1975 dollars. And I am going to confuse you, because I am going to jump back and forth into different year dollars, but I will try to relate them, if I can.

We used that policy and sold out the first 3 years of shuttle flights at that price. When I first addressed this in 1982, we, of course, were a year into the flight schedule, and it was necessary to look at the second period of time.

Now, we decided at that point to set a fixed price for a further 3 years. The reason we picked 3 years is that it is about the minimum time that you can pick that gives your customer base some assurance of the supply of services long enough in advance that allows them to plan: because if you are buying a satellite, for example, you generally have a lead time of 3 to 5 years. So, if you are going to make commitments, you have got to be able to know and base your economic analysis on what it is going to cost you to put your satellite in orbit. So, we felt 3 years was about the minimum time that we could set, and we chose a further 3 years. We set that price at $71 million in 1982 dollars which equates to $38 million as compared to that original $18 million in 1975 dollars. We did that on the basis of what we then knew the costs of the shuttle were on an additive basis or on an incremental basis, if you will.

That is what I referred to earlier as once you have established the basic capability, that is about what it costs you in out-of-pocket expense. It is not truly incremental, but it is out-of-pocket expense. We added a few items to that price to cover some of the miscellaneous charges for reflight insurance, and we added a contingency to it of $6 million, and that is how we got to the $71 million price.

When we set that, it was determined by the OMB and the administration in the deliberations we had on the pricing issue that the next pricing period would be set to what was described as full cost. Full cost we interpreted to be the full operational cost of the shuttle. Now, we then proposed most recently that we establish a price for the subsequent 3 years. That starts late in 1988 and goes through 1992—no, it goes through 1989, 1990, and 1991. We set that price at $83 million, and we added a contingency to that of $4 million and set a total price of $87 million and said that with that price we reserved the right to decrease 5 percent, if market conditions demanded. And that is where we are today.

The proposal we have made has not been fully approved. That price is being considered and discussed by the Cabinet Council on Commerce and Trade—I think that is the correct description—as was described in the Presidential Directive. Then, it will go to the NSC for final approval. When that will occur I am not quite sure, probably in the next few months. We are still arguing in some cases the details of how we got to the $83 million total cost figure.

Since that time, several new factors have developed, not the least of which is that we are being underpriced in the marketplace in the current pricing period, which is of concern to us. Second, there are some new facts on the table with respect to the prospective costs of expendable launch vehicles, which also is a factor in the consideration of the price of the shuttle.

Senator GORE. Well, we are going to have, as I understand, a separate hearing just on this issue, and after the Cabinet Council gets through with it, the Congress may have to make the eventual decision on that. I look forward to working with the chairman on that.

One final question, and that is about the discussion that I have been hearing a little bit about; that is, the exploration of the possibility of a manned Mars mission with participation from the Soviet Union. Is that just a figment of somebody's imagination, or how far have those discussions gone?

Mr. BEGGS. Yes, it is a figment of my imagination, and others. No, there have been no discussions with the Soviet Union.

Senator GORE. I meant discussions in the administration.

Mr. BEGGS. No, there have not been any serious discussions in the administration. Obviously, if one were to want to do such a mission, it would require the initiation of some planning, depending upon when you wanted to do it, probably out in the 1990's. And you are talking about a mission that no doubt would be a prospective mission for maybe the year 2015 or some date like that, so it is a long way out. I do not think there needs to be at the present time any serious planning or even agreement.

The Soviets, interestingly, have stated publicly that they are interested in a manned Mars mission. They are also interested in some unmanned Mars activities. Mr. Sagnyev, the civil leader of the Soviet space program who is a member of the Soviet Academy and runs the civil activities, was in this country recently. He was talking about both the near term—and by near term, sometime in the next 6 or 8 years—an unmanned mission to Mars that he felt could be a useful collaboration between the United States and the Soviet Union. And he also was, I guess, sort of speculating on the potential of a manned voyage sometime in the distant future. Such a mission would involve a very, very significant commitment of resources. It would be something that would be, I think, a very likely mission for international collaboration not only between the United States and the Soviets, but perhaps between the United States, the European Space Agency, the Soviets, and the Japanese. We could use all their help if we were to mount such a mission. It is a difficult one to conceive of because it is a 200-day one-way journey. You would want to do a lot of things that we currently do not have the technology to do. And if you are going to go, you would want to take along the necessary equipment to allow you to do a significant exploration of the planet.

There are some very interesting features on Mars that we discovered with our unmanned probes, and you would want to do as much exploration of the planet as you possibly could after having expended that much money and effort to get there. But, it is kind of interesting to speculate on, and I suspect we will continue to speculate on it into the future, although I doubt whether anybody is going to make any kind of a commitment to it in advance of maybe the mid-1990's or even toward the end of the century.

Senator GORE. OK. Thank you. And thank you, Mr. Chairman.

Senator GORTON. Mr. Beggs, I understand you have just revealed a problem related to the shuttle's Centaur Program which could cost NASA and/or the Air Force an extra $60 or $70 million. How are you going to share the cost and resolve the problem, both from a scheduling and budgetary standpoint? And will it affect the 1986 launches of the Galileo and Ulysses Shuttle Centaur missions?

Mr. **Beggs**. We do not think that it will affect the schedule. We certainly are working very hard to make sure that it does not affect the schedule, because the Galileo is tied to the Centaur, and the ISPM is tied to the Centaur. And so we want very much to remain on the schedule we are on, and we think we can. But we have overrun the cost by perhaps as much as $50 or $60 million. Our agreement with the Air Force was drawn in such a way that it did set ceilings, but the ceilings were above the then-projected cost. We will share the projected increase 50/50 with the Air Force up to the ceiling we have set, which was set in their case at $150 million, and we are still within that envelope. If we have further growth, though, we will have to look to our own resources for the whole increase; but we think we are well within that right now.

Senator **Gorton**. Are you meeting all of your milestones for launching the space telescope in 1986?

Mr. **Beggs**. I wish I could say yes, but the answer is "no." We are currently about 2 months behind on the key milestones—the assembly and test of the entire assembly out at Lockheed. The primary problem there has been software, that modern bugaboo of all programs; and we are currently in the process of reworking our software. This is software which was designed for the test program. It is such a complex instrument that to test it manually—that is, to continue to test it and then refer back to manuals would be terribly time consuming and laborious. So we designed a software program to allow us to go ahead and test it in an automated way or semi-automated way. We found when we got into it that the software is not performing as it should, so we are having to go back and rebuild the software, which has set us back about 2 months.

With that setback we have gone back, regrouped, and done some additional manning in certain areas. We believe that we still have something like 2 months of reserve time, 2 months slack, if you will, on the launch schedule we project of August, I think, 1986. So, we think we are still all right on the launch. But we have slipped, and that is of great concern, and we have been reviewing this program very rigorously for the last couple of months.

We still feel that we are within our budget projection, but there is not enough—we are not underrunning by any manner or means. We are right against the instrument.

Senator **Gorton**. How about the operations and maintenance cost? And are these costs going to affect NASA's ability to initiate new science missions and to conduct the ongoing research and analysis activities?

Mr. **Beggs**. Well, I think the O&M cost can be contained in the estimates we have made. We have a couple of possible surprises awaiting us in the cost of operating the Space Telescope Institute, which we will be working hard to contain those.

But I think the figures that we have given the Congress for maintenance and repair and refurbishment are figures that we would be willing to stand by.

Now, it is a substantial amount of money. It is over $300 million up through fiscal year 1990 that buys in the spare parts and various and sundry activities. And then, in addition to that, as I mentioned, we have the operating costs, which include the Institute and the other activities necessary to keep the telescope full up, which you certainly want to do having spent the kind of money we have on it, which add up to another, well, about $60 million per year. Those costs are somewhat higher than they were when we initiated the project. However, they are still within the estimates, I think, that we gave to this committee a year or so ago.

Senator GORTON. One last question on another subject. NASA asked for about $25 million for an advanced composite systems technology program, but OMB terminated the program after two years of study and approximately a $24 million investment.

Can you describe OMB's justifications for the termination of the program and whether or not you believe that industry is capable of performing this research and development on its own?

Mr. BEGGS. The justification was that the industry was picking up on the composite structures, and indeed they are. They are starting to do more and more and designing into aircraft both primary and secondary structure out of composites. And I feel comfortable with that, yes, sir. I cannot argue that one too vigorously. There is a substantial program ongoing. If we had continued the program, we would probably have pushed the art forward a little faster than the industry will, but I do not think significantly faster.

Senator GORTON. I have a number of other questions, Mr. Beggs, but we have had you here for more than an hour and a half, and I will submit them in writing. And Senator Gore will do the same.

Senator GORTON. Thank you very much, sir.

Mr. BEGGS. Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF HON. JAMES M. BEGGS, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Distinguished Members of the Subommittee:

It is a pleasure for me to appear before this Subcommittee to present President Reagan's budget request for NASA for FY 1986. The total NASA request is $7.9 billion, of which $2.9 billion is for Research and Development, $3.5 billion for Space Flight, Control and Data Communications; $149 million for Construction of Facilities; and $1.3 billion for Research and Program Management. The NASA budget for FY 1986 provides for solid progress toward the Aeronautics and Space objectives approved by the Administration and the Congress.

SPACE STATION

In response to President Reagan's directive of last year to develop within a decade a permanently manned Space Station, NASA has begun a major new endeavor, one that I believe will ensure United States leadership in space during the decade of the 1990's and beyond, while at the same time providing a sound framework for a mutually beneficial cooperative program with our friends and allies abroad. Progress, so far, has been substantial.

We have initiated a competition within U.S. industry for Space Station definition and preliminary design that is scheduled to commence in April of this year and lead to a thorough understanding of Space Station systems prior to hardware development. We have begun a technology development program that will enable us to incorporate the proper level of advanced, sophisticated systems aboard the Station. In accordance with the President's directive, and as a follow-up to the results of the London Economic Summit at which the attending nations welcomed the U.S. invitation to participate in the Space Station development, we have held extensive discussions with representatives of the European Space Agency, Canada, and Japan. These discussions should lead initially to their own Space Station definition studies, in parallel with ours, and ultimately to a partnership in Space Station hardware development and use. We have established a Space Station management structure that designates the Johnson Space Center in Houston as "Lead Center" while fully utilizing the talents of other NASA installations. We have also established a strong user or customer focus to the Space Station Program, reflected organizationally in our creating Space Station Chief Scientist positions at both NASA Headquarters and the Johnson Space Center. It is reflected too in the utilization of a specially constituted Space Station Science Advisory Committee chaired by Dr. Peter Banks of Stanford University and by the emphasis we've placed upon Space Station mission requirements. Advocacy groups have been established to represent customer requirements for potential commercial, scientific, and technology development payloads and these will be incorporated in the definition and preliminary design studies that begin in the spring.

As we've undertaken these activities, we have been mindful of the directives received from Congress last year when it approved the Agency's budget request of $150 million to begin the Space Station Program. The study of a "man-tended" approach, requested by Congress, has been set in motion by its incorporation in the definition and preliminary design activity; U.S. industry will examine this option in conjunction with the main body of analysis. The Advanced Technology Advisory Committee has been established to analyze, and report to the Congress upon the potential for advancing the technologies of automation and robotics. This analysis will be utilized by U.S. industry as it conducts the Space Station definition studies. Reports on Space Station management and platform selection criteria have also been prepared and submitted in response to requests from this Committee.

The Station will consist of a manned base with accompanying unmanned platforms, one of which is likely to be in polar orbit. The base and platforms would be carried aloft in modular sections by the Space Shuttle which would assist in the on-orbit assembly and check-out of the Space Station. The Shuttle would also be used for logistics resupply and crew rotation. By utilizing both manned and unmanned elements, the Space Station will enjoy the substantial advantages offered by both modes of space flight. Combined with the unique advantages provided by a truly permanent presence, the Station will significantly enhance United States capabilities in space.

The Space Station will be a versatile and effective facility, serving a diverse range of functions. It will be:

- a national laboratory in space, for the conduct of science as well as the development of new technologies and related commercial products;
- a permanent observatory, to look down upon the Earth and out into the universe;
- a servicing facility where payloads and spacecraft are resupplied, maintained, upgraded and, if necessary, repaired;
- a transportation node where payloads and vehicles are stationed, processed and propelled to their destinations;
- an assembly facility where, due to ample time on orbit and the presence of appropriate equipment, large structures are put together and checked out;
- a manufacturing facility where human resourcefulness and the servicing capability of the Station combine to enhance commercial opportunities in space;
- a storage depot where payloads and parts are kept on orbit for subsequent deployment, and
- a staging base for future endeavors in space.

The Space Station will also be:

- a striking example of Free World unity and capabilities; and
- a highly visible yet peaceful demonstration of U.S. leadership.

In FY 1986 NASA is requesting $230 million for Space Station activities. During the fiscal year the Space Station definition and preliminary analysis will be under way. The advanced technology development activity will be in progress while user payload requirements will be refined and updated. In addition, a highly innovative Technical Management and Information System will be established to enhance overall program management and a Space Station operations concept will be developed. Our current schedule envisions that Space Station hardware development will begin in 1987. This schedule allows for international partners in the Space Station Program to work in step with NASA. As importantly, it enables NASA to work toward the objective of having a Space Station within a decade. From that time forward, I believe there will always be Americans living and working in space.

SPACE SHUTTLE

The President has directed that NASA's first priority is to make the STS fully operational and cost effective in providing routine access to space. He has also directed that the STS program will receive sustained commitments by all affected departments and agencies and directed that enhancements of STS operational capability, upper stages and efficient methods of deploying and retrieving payloads will be pursued as national requirements are defined.

While I am extremely proud of our record of 15 highly successful launches, I recognize that it is essential that we continue to move forward to drive down Shuttle costs and provide the opportunities for further commercialization of space so that this country can compete effectively in the international arena and maintain its leadership in space. I am concerned that we might find ourselves in the same situation in the space industry that we now find ourselves in the automobile industry. We cannot look at space launches without also looking at the long term impact on the satellite manufacturers, the upper stage industry and the other infrastructure we have built up in this country over the last 26 years. With aerospace and agriculture contributing effectively to helping alleviate our balance of payments problem it is essential that we take additional steps to ensure that these jobs are not lost to the U.S. economy.

The STS capability includes a highly competent, experienced STS team; the four Orbiter fleet - Columbia, Challenger, Discovery, and Atlantis; commercial and government upper stages, two Launch Pads at the Kennedy Space Center; the Vandenberg Launch Site; production capabilities and facilities to support 24 flights per year; and the dedication and experience to provide customers easy access to space.

At the present time two of our Orbiters, OV-099 Challenger and OV-103 Discovery, are operational, OV-102 Columbia is undergoing modifications and OV-104 Atlantis has a planned April 1985 delivery.

While the Shuttle team has an unblemished safety record, we must ensure that each mission is safe and reliable. Our planning during the next few years focuses on bringing the STS to operational maturity. This includes: essential modifications to the Orbiter fleet, improved life and operating margins on the main engines, particularly the high pressure pumps, and ensuring that an improved operational capability is in place. It is also essential that we provide increasingly efficient and customer friendly operations for Shuttle and Spacelab users. We are working with DOD to prepare for manned space operations at Vandenberg Air Force Base and the Shuttle Operations and Planning Center at Colorado Springs.

This year saw the first full year of operations at Kennedy Space Center (KSC) under the Shuttle Processing Contract and the Base Operations Contract. Both contracts continue to show increased efficiencies. At the Johnson Space Center we are planning a Space Transportation System Operation Contract to consolidate work now being performed by 16 contractors into a single contract.

Two of the highlights in the Space Program this past year which hold great hope for the future are the retrieval and repair of the Solar Maximum Mission satellite and the retrieval of the Westar and Palapa communication satellites. The Solar Max spacecraft had been launched in 1980 but was disabled by the failure of its fine-pointing system. The Solar Max repair mission enabled the satellite to resume its program of solar observations and measurements. The Westar and Palapa satellites were spectacularly retrieved on our November mission and brought back to Earth. They are currently being refurbished and we understand that the space insurance industry is in the process of reaching an agreement on their resale.

In FY 1985 we plan 10 Shuttle flights including two dedicated DOD missions, two Spacelab missions, the deployment of 15 communication satellites, and the second TDRSS launch using the IUS, the third TDRSS will be launched later in 1985. 1985 will also see the completion of the upgrading of Columbia and the inaugural flight of the fourth Orbiter, Atlantis.

Our FY 1986 budget request for the Space Transportation System Program is $3160.9 billion. This supports 14 missions, or an average of one approximately every 25-30 days, with the scheduling dominated by the planetary launch window in May. Pad B at KSC will be brought into service in time to support the Galileo Jupiter launch, only six days after the Ulysses (International Solar Polar Mission) is launched from Pad A. The missions include four Spacelab flights, launch of the Hubble Space Telescope, numerous communications satellites, two flights of the McDonnell Douglas pharmaceutical pilot production module, the first flight from Vandenberg AFB, one other dedicated DOD mission, two payloads to make observations of Halley's Comet, and several materials processing payloads.

With the flight rate increasing and the Orbiter production program winding down, there is continued emphasis on Orbiter spares and the Space Shuttle Main Engine. The initial increment of structural spares has been defined, negotiated and production is underway with deliveries scheduled thru 1987. This provides a set of major structural components to be used in the event of major damage to an Orbiter, while helping to maintain a production base, and potentially reducing the lead time to build an additional Orbiter, if one should be required in the future. Since last year, there has been a major re-planning of the Space Shuttle Main Engine (SSME) Program, with a focus on limiting the scope of improvements to increase operating life and design margins of the current configuration. In addition, we are establishing an advanced development effort having two major thrusts; alternative engine contractors and a technology test bed.

Major efforts in the launch and landing area include activation and readiness of launch pad B, activation of the third Mobile Launch Platform and modifications to provide the capability to service the Centaur upper stage for the initial Centaur flights. Construction of the new Solid Rocket Booster (SRB) refurbishment and assembly facility at KSC will be completed. The fabrication of filament wound case (FWC) segments will continue and the development testing will be completed.

The Orbital Manuevering Vehicle (OMV), a reusable, remotely piloted system which represents a significant extension of capability for the Space Transportation System will be initiated in 1986 and be available for flight use in 1990.

SPACE SCIENCE AND APPLICATIONS

The Space Science and Applications program has had impressive results this past year. Some which are particularly noteworthy include the completion of the IRAS mission, the restoration of the Solar Maximum Mission, the flight of the Shuttle Imaging Radar-B and the Large Format Camera, the launch of the Active Magnetospheric Particle Tracer Explorers, Earth Radiation Budget Experiment, and a host of other first-rate scientific achievements.

The budget request for Space Science and Applications of $1613.2 million will support the continuance of a healthy and scientifically challenging program. Space Science will experience a banner year in 1986 as past investments become reality. Early in the year a special set of three telescopes known as the ASTRO payload will fly aboard the Shuttle to make observations of Halley's Comet. The Voyager Spacecraft will encounter the planet Uranus in 1986, to give us the first close-in observation of that large, unusual and unexplored planet and then continue on its way to Neptune. The Galileo Mission will also be launched in late Spring of 1986. An option has recently been added to the Galileo mission to allow for the spacecraft to fly by and observe the asteroid Amphitrite while on the way to Jupiter. The Galileo orbiter/probe will encounter Jupiter in December 1988 where the probe will be sent into the dense atmosphere of that planet while the orbiter spacecraft remains in orbit to obtain additional data on the planet and to take a close look at its satellites. During the same planetary launch window, the Ulysses spacecraft, will be launched toward Jupiter and will use the tremendous gravitational force of that planet to accelerate into a trajectory that will permit inspection of the Sun at high latitudes never before available for observation.

Later in 1986, the Hubble Space Telescope will be launched into Earth orbit to provide resolution far superior to that available in even the best ground-based telescopes and thereby providing a quantum jump in our ability to observe and understand the Universe. The Space Telescope like Galileo and Ulysses involves extensive contributions from our European partners. We will continue working aggressively on other ongoing space science and applications missions including the Gamma Ray Observatory, the Cosmic Background Explorer, the Extreme Ultraviolet Explorer, the Venus Radar Mapper, the Upper Atmosphere Research Satellite, and the Mars Observer.

The Life Sciences budget will allow continuation of work to ensure astronaut health and productivity in space. It will also support the activities needed to ensure success in establishing a permanent presence in space with the Space Station.

Our Space Applications program will be supported at the $551.8 million level. Consistent with the congressional action on the FY 1985 budget, we will be pursuing development of the Advanced Communications Technology Satellite planned for launch in 1989 to demonstrate the technology needed for the United States to remain competitive in this important area.

This funding level will allow for the continued development of the Upper Atmospheric Research Satellite and the NROSS Scatterometer as well as the critical research in solid Earth and environmental observations. We will also continue ongoing development efforts in Materials Processing and Information Systems.

Although FY 1986 will be a vigorous year for the Space Science and Applications program, it has been necessary to defer initiation of new projects. I believe the hiatus in FY 1986 is reasonable provided we make appropriate provision for new initiatives in future years.

COMMERCIAL PROGRAMS/TECHNOLOGY UTILIZATION

In support of the National Commercial Space Policy and the amended National Aeronautics and Space Act of 1958, NASA in 1984 established the Office of Commercial Programs to pursue new ways of reducing the technical and financial risks of doing business in space. The Commercial Programs Office will provide a focus for a NASA-wide program to encourage U.S. private investment in commercial space ventures and facilitate commercial application and transfer of existing aeronautics and space technology.

The FY 1986 request of $30 million for Commercial Programs will continue and expand a series of initiatives begun in FY 1985 to support the National Commercial Space Policy and to implement NASA's Commercial Use of Space Policy. These initiatives will help stimulate research and development by aerospace and non-aerospace companies; increase access to NASA's facilities and equipment; establish new links with the private sector and establish centers to provide for the commercial development of space.

NASA's FY 1986 proposal of $11.1 million for Technology Utilization will allow continued effort to transfer NASA-developed technology to U.S. industry, the public and other Government agencies.

AERONAUTICAL RESEARCH AND TECHNOLOGY

NASA is requesting $354.0 million in FY 1986 for Aeronautical Research and Technology to provide the broad technology base essential to the preservation of U.S. leadership in aviation. The program includes fundamental research in the aeronautical disciplines and a carefully selected group of focused systems research directed at the interactions of disciplines and components and the evaluation of new concepts.
Key elements in FY 1986 include the Advanced Turboprop program which is developing single- and counter rotation propeller and aircraft integration technologies for a new generation of fuel efficient aircraft. Critical technology gaps are being addressed through proof-of-concept testing of the unducted fan and flight testing of a large-scale advanced propeller in FY 1987 as directed by Congress. In addition, the Numerical Aerodynamic Simulation Program will begin to provide the U.S. with the world's most advanced capability for numerical simulation of aerodynamic flows about an aircraft and through the rotating turbomachinery of engines. The initial system will be brought to operational status in FY 1986.

Flight research activities to explore the operating characteristics of the DARPA/NASA X-29 forward swept wing research aircraft will continue and the DARPA/NASA X-wing rotor research aircraft is being readied for first flight in early FY 1987. Similar activities are planned in conjunction with the Navy to develop an oblique wing research aircraft.

SPACE RESEARCH AND TECHNOLOGY

The FY 1986 Space Research and Technology request of $168.0 million provides for modest growth in a broad base of advanced technologies contributing to the Agency goals of improved operational effectiveness of the Space Transportation System; an efficient and productive Space Station; and to enable the United States to lead in the exploration of the solar system and observation of the Earth from space. It also supports expanding military and commercial space needs with technological options which make future space systems and applications a practical and economical reality.

Major programs in FY 1986 include: research on advanced components and diagnostic instrumentation to improve the life and performance of large LOX/hydrogen engines leading to tests in a SSME test-bed engine; vehicle and propulsion technologies directed at the critical needs for a reusable, space-based orbital transfer vehicle; automation research addressing teleoperations and robotics for spacecraft and Space Station applications; development of in-space experiment capabilities to provide the technology base for cryogenic fluid management, large thermal energy systems; and to investigate the dynamics and control of large, flexible structures. Experimentation in space is critical to the development and verification of future space systems and commercial applications and will be an important focus of the space R&T program. Significant events occurred in this area during 1984. The Long Duration Exposure Facility (LDEF) was deployed in April and is scheduled to be retrieved in March 1985. It will be returned to Earth so that the long-term effects of space exposure can be evaluated on selected materials and components. In August, an experimental, 100 foot solar array was deployed from the Shuttle Orbiter Discovery cargo bay. The array was instrumented to provide the first research data on the dynamic response of large, highly flexible structures.

SPACE TRACKING AND DATA SYSTEMS

For the Space Tracking and Data Systems Program, NASA is requesting a total of $824.5 million for FY 1986. These funds will provide for the continuation of the vital tracking, command, telemetry, communications, and data processing support to meet NASA flight program requirements. The transition of the ground tracking network to a space tracking capability for low Earth orbit missions is continuing. This transition began with the launch of TDRS-1 in April of 1983. Since the dramatic recovery from the upper stage failure, the TDRS-1 has successfully supported the various Shuttle missions, as well as Spacelab, Landsat, Solar Mesopheric Expolorer, Earth Radiation Budget Experiment, and the Solar Maximum Mission.

The required satellite constellation will be completed with the launches of TDRS-2 in February of this year and TDRS-3 later this year, and full operational capability of the space network will be achieved with the completion of the required checkout and testing.

The Ground Networks, composed of the residual Space Tracking and Data Network (STDN) and the Deep Space Network (DSN), will continue to provide tracking and data support to a variety of missions during FY 1986. In anticipation of the TDRSS full operational capability, we are continuing to make substantial reductions in our ground tracking network which supports near-Earth spacecraft. The STDN is now half the size it was five years ago, and most of the remaining stations will be closed or transferred to other agencies when TDRSS becomes fully operational.

The Deep Space Network, which provides the only means of communications with our deep space and interplanetary missions, is on the threshold of an especially active and critical period. The Networks Consolidation Program is scheduled to be completed by the end of February 1985 which will permit the DSN to assume support responsibility for spacecraft above the view of the TDRSS as well as for those older spacecraft which are not compatible with TDRSS. A major DSN upgrade is scheduled for completion in the Fall of 1985 which will allow us to meet the increasingly complex mission needs.

Two major activities in NASA's Communications Program will become operational in FY 1986, both of which will employ available advanced technologies developed by the communications industry--a Time Division Multiple Access system which will provide operational circuits via satellite, and a Program Support Communications Network which will handle NASA's growing non-operational communications needs among its Centers.

CONSTRUCTION OF FACILITIES

Of the FY 1986 Construction of Facilities request of $149.3 million, approximately one-third is allocated to essential repairs, rehabilitations and modifications, and minor construction, while approximately one-half is allocated to 14 major projects in support of critical programmatic requirements. The budget provides needed facilities support for Space Shuttle operations and related activities such as the construction of an Orbiter Modification and Refurbishment Facility at KSC and modifications for an Advanced Technology Engine Test Stand at MSFC.

Three major facility projects in support of Space Science activities are also included. A Micro-devices Laboratory at JPL will provide the necessary environment for conducting microelectronics research and technology development for solid state devices, spaceborne very large scale integrated circuits, and advanced computer architecture. At Goddard Space Flight Center, the budget request will permit the construction of the initial phase of a Spacecraft Systems Development and Integration Facility. This project, when completed with a similar amount in next year's budget, will provide the capability for developing and integrating spacecraft of sizes that can exploit the full capability of the Shuttle.

Facility projects in support of Aeronautics and Space Technology include the second increment of funding required to complete the Numerical Aerodynamics Simulation Facility at Ames Research Center and modification of the 16-foot Transonic Tunnel at Langley Research Center for improved productivity and research capability.

RESEARCH AND PROGRAM MANAGEMENT

The NASA institution is appropriately sized and capable of carrying-out the FY 1986 program. In the FY 1986 Research and Program Management Budget, there are, however, two significant changes from FY 1985; first, the salary rate for civil service personnel is five percent lower in FY 1986 than FY 1985. This reduction in salary rates is part of the Government-wide reduction directed by the President beginning in 1986. The other major change has been a reduction of 200 civil service FTE's and $21.0 million related to the President's drive to reduce administrative costs in the Government. We will endeavor to accomplish the reductions in a manner to minimize the impact on program accomplishment. The balance of the changes in R&PM reflect a constant level of operations at expected price levels.

Mr. Chairman, I am satisfied that the budget we are requesting for FY 1986 is a reasonable budget considering the constrained fiscal environment in which all programs must be considered and I am satisfied that we can and will achieve substantial progress toward all of the Nation's major objectives for which NASA is responsible.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Fifth Orbiter

Question 1: With no decision having been made to purchase a fifth Orbiter, how long can NASA continue to maintain the operation of the Orbiter production lines?

Answer 1: The Orbiter production line at the major structural subcontractors will begin closing down with the delivery of the structural spares mid-fuselage in early FY 1986, and concluding with final delivery of structural elements in late FY 1987. The subsystem production capability is coupled with the orbiter operational logistics program and will be ongoing for the majority of the subcontractors, through FY 1988. Therefore, although certain skills will be lost at Rockwell International and selected subcontractors the nucleus for an OV-105 production capability will be maintained by our current programs through FY 1986.

Question 2: For the past two years, Congress has augmented the NASA budget by some $40 to $50 million a year to maintain production readiness for a fifth orbiter. Would a similar augmentation for FY 1986 be a wise allocation of resources, or do the realities of the projected Shuttle demand make this an unwise allocation of resources?

Answer 2: We feel the current funding level for the structural spares and logistics program is adequate to maintain the skill levels through FY 1986, required to maintain the option to begin building a fifth orbiter and an augmentation is not required.

Space Station

Question 3: Are you and the U.S. aerospace industry satisfied with the technologies and elements that the international participants are pursuing during their Phase B studies, or are they pursuing some technologies that you believe should be NASA's contribution to the core technology of the station?

Answer 3: As successfully demonstrated in past cooperative programs, each partner assumes full financial and technical responsibility for their respective projects. This principle has been adopted by NASA as a primary guideline for international cooperation in the Space Station program. Our potential partners have identified elements such as pressurized laboratory modules and polar and low-inclination platforms as candidates for cooperation. NASA views these potential cooperative elements as ones which could significantly enhance the overall capability of the Space Station.

Shuttle Pricing Policy/Shuttle Manifest

Question 4: Concerning the ongoing negotiations related to a new Shuttle pricing policy for fiscal year 1989, I understand that NASA's proposal is $87 million for a Shuttle mission that is dedicated to commercial users.

How competitive would NASA be with Ariane if this Shuttle pricing policy were implemented?

Answer 4: Currently, the Shuttle is competing with Ariane for launches in 1986, 1987, and 1988. The Shuttle price for this period is $71.0 million (1982 dollars). At $71 million, Ariane is winning a minimum of 50 percent of the market. Should the Shuttle price go up, Ariane will also probably raise their price. However, while Ariane may raise prices somewhat, their margin for "predatory" pricing will be greater. It is highly likely that--within its capacity-- Ariane could capture a larger share of the market.

Question 5: What assumptions can be safely made about Ariane's pricing policy if the Shuttle's prices are raised--will Ariane raise its prices to a level that closely approximates those of the Shuttle or will Ariane make only minor adjustments in its prices?

Answer 5: To the extent that Arianespace's current pricing represents discounts below its full cost recovery level, it is reasonable to assume that Arianespace will raise its prices if it is competitively possible to do so. At the same time, Arianespace's, publically stated, full cost recovery prices fall below prices for comparable payloads based on a Shuttle price of $87 million in the FY 1989 and beyond period. If Arianespace is able to achieve a real profit below Shuttle prices, we believe its motivation to raise its prices further will be dependent on its capacity and world demand. Arianespace will likely price against all competition (Suttle and U.S. ELVs) so as to capture its desired market share--extensive escalation of Shuttle prices above U.S. ELV prices would probably not induce Ariane prices to rise above those of U.S. ELVs as well.

Question 6: Your $87 million Shuttle pricing policy supposedly reflects full cost recovery. However, other interested parties suggest that a pricing policy of almost double your proposed price would more accurately reflect full cost recovery for the Shuttle. Can you comment on what items related to Shuttle costs might account for the disparity in these two proposed pricing policies?

Answer 6: The price NASA proposes is based on recovery of full operational costs (consumables used in preparation and flight, launch operations, at KSC, flight operations costs at JSC, MSFC, and JSC, and global tracking network). The higher Shuttle prices propose to recover development costs of this national asset and, in some cases, the capital costs (interest, facilities, equipment, tooling, insurance, etc.,).

Question 7: Since Ariane has captured 50 percent of the communications satellite launch market over the past fourteen months, how likely is it that Ariane will maintain or possibly increase its share of this market at the expense of the Shuttle or a U.S. ELV industry?

Answer 7: Arianespace has resorted to steep discounts in order to assure that its bids to launch customers have undercut the Shuttle even in the FY 1986-1988 pricing period. As the question notes, these aggressive discounts have made inroads in the commercial launch market beyond Arianespace's publicly acknowledged goals. NASA believes that Arianespace has the potential production and launch capacity to serve a dominant share of the commercial market in the period under consideration. Thus, we judge that there would be no incentive for Arianespace to hold down its market share under these conditions. On the contrary, because of the possible benefits to European industry (satellite and ground station manufacturers and suppliers as well as industry directly involved in the Ariane vehicle), Arianespace is motivated to capture as much of the market as it can up to the limits to its capacity.

Question 8: If this pricing policy is implemented, how confident would you be that it will not discourage companies from investing in Shuttle-related commercial space ventures?

Answer 8: The increased Shuttle price may not drive companies away from the Shuttle-related commercial ventures but will reduce those who are only marginally profitable or have a long term or uncertain payback considerably. For example, Mr. James Rose, Director of Space Processing at the McDonnell Douglas Company, has stated recently that the increase in price has reduced the number of products they were considering for space production from eleven to four and that any further increase in price would reduce the number of products to only one that would be developed and marketed.

Air Force Refurbishment of Titan II Missiles

Question 9: How does the movement of these NOAA and Air Force payloads to the Titan IIs affect the Shuttle manifest, Shuttle economics, and in particular, the ongoing Shuttle pricing policy negotiations?

Answer 9: Overall, the decision by the Air Force repesents the potential loss of approximately one-half to one equivalent Shuttle flight per year, from the Vandenberg launch site. Because of the "marching army" base required to support the STS, every mission launched by expendable launch vehicles will impact the Shuttle program from the standpoint of cost and utilization, assuming the Shuttle has the excess capacity available to conduct the mission. The assessment of the problem is a matter of attempting to determine firm mission schedules for years in advance of launch, which is difficult to predict. We are currently assessing the potential impact. We do not,however, expect it to impact Shuttle pricing policy.

Question 10: With a total of some 50 Titan II missiles being phased out of service by the Air Force, do you suspect that there will be additional government or commercial payloads moving off the Shuttle to these Titan IIs?

Answer 10: Although there could be some additional Government usage of Titan IIs, we cannot comment on the commercial use of the USAF vehicle.

Air Force Complementary Expendable Launch Vehicle (CELV)

Question 11: When do you expect a decision concerning the Air Force selection of either the modified Titan or NASA's SRB-X for its Complementary ELV?

Answer 11: We understand that the DOD has selected the Titan III (34) D-7.

Question 12: How confident are you that the Air Force will not launch more than the ten CELV's that it is presently planning to launch during fiscal years 1988-1992?

Answer 12: NASA prefers not to speculate on that subject, which is subject to DOD decisions and funding.

Question 13: Is NASA discussing with the Air Force the possibility of a cancellation fee for any payloads it will move off the Shuttle?

Answer 13: NASA and DOD are jointly developing a pricing policy for DOD flights that provides a positive incentive for flying on the Shuttle. The pricing policy will be based upon the principle that an agreed reimbursement will be comprised of a fixed and variable component resulting in an annual fixed fee and a charge per flight at marginal or incremental costs. The base flight rate for this commitment will be on the order of 8 flights per year (one-third of the capability).

U.S. - Soviet Space Cooperation

Question 14: Last year, Congress passed legislation direting the President to renew the U.S.-Soviet Union space cooperation agreement that expired in 1982. Could you tell us the status of these negotiations?

Answer 14: The President signed Senate Joint Resolution 236 into law on October 20, 1984. At the time of the signing, he stated his desire to increase contacts and work with the Soviets on cooperative space programs which are mutually beneficial and productive. NASA is currently supporting scientist-to-scientist contacts and data exchanges with Soviet counterparts in the life sciences and in planetary research. In addition, an U.S. experiment will be flown on the next Soviet Cosmos biosatellite mission to be launched next summer. There are also several multilateral cooperative activities underway which include U.S. and Soviet participation, such as the Inter-Agency Consultative Group (IACG) on Halley's Comment and the COSPAS-SARSAT satellite search and rescue system. We remain interested in further broadening our cooperative activites to other mutually-beneficial areas. However, there are no negotiations currently underway concerning the government-to-government space agreement.

Question 15: Also, last July, the President proposed a joint U.S./Soviet manned space mission to demonstrate space rescue techniques. Lately, as you know, there have been scattered reports concerning this proposal. How receptive has the Soviet Union been to this proposal, and what progress, if any, has been made toward reaching an agreement with the Soviet Union for this joint rescue mission?

Answer 15: Thus far, the Soviet Union has not given a substantive response. but the U.S. proposal remains on the table. If and when the Soviets respond, NASA is prepared to discuss the specific with them.

Commercial Programs Office

Question 16: The creation of the Commercial Programs office should play a significant role in broadening the interest and involvement of many companies in commercial space activities that heretofore have been limited or nonexistent. While I know that there is a long lead time for the realization of most commercial space activities, what immediate benefits can we expect from the efforts of the Commercial Programs office?

Answer 16: A key objective of NASA's Office of Commercial Programs will be to strengthen the research and development foundation that will stimulate industry-funded commercial product development. This office will also serve as a focus for an Agency-wide program that will assist in reducing the technical, financial, and institutional risks of doing business in space.

Immediate benefits to be derived from the formation of the new commercial programs office are both internal and external. Internally, the priority being given to encouraging the commercial use of space will serve to enhance the sensitivity and responsiveness of the NASA system to encouraging commercial space endeavors. Externally, a highly visible NASA Commercial Programs Office will serve as an catalyst to commercial space investments that will eventually yield significant economic and social returns.

QUESTIONS OF SENATOR HOLLINGS AND THE ANSWERS

General Budget Questions

Question 1: At a time when there are several proposals circulating on the Hill for agencies' budgets to be pared back or frozen at the FY 1985 level, why should the Committee exempt NASA from this standard and approve a 5.3 percent increase over the FY 1985 baseline?

Answer 1: NASA's FY 1986 budget request is already nearly level with FY 1985 after providing for inflation. A freeze at the FY 1985 level would reduce the NASA request by about $400 million. Absorption of a reduction in funding of this magnitude would require a major restructuring of the entire NASA budget. The newest projects with the least investments, such as the OMV, ACTS, ATP, Commercial Use of Space, etc. would be delayed or deferred. Finally a reduction of this magnitude would have a ripple effect throughout the NASA organization through the breakup of research teams, changes in detailed project schedules and deferral of testing and integration activities which, when combined with the effects listed above make it a certainty that a budget freeze at the FY 1985 level would have a major adverse impact on NASA.

Question 2: Should all research and development activities in all agencies be exempted from the budget freeze?

Answer: The conduct of research and development helps assure the strength of the economy and the national defense,, and to assure the quality of life for all people. The President's FY 1986 budget request reflects the relatively high priority the Administration gives to research and development. We do not feel it is appropriate for NASA to comment on whether all research and development activities for all agencies should be exempted from a budget freeze.

Question 3: The Congressional Budget Office recently proposed two budget options that would reduce NASA's FY 1986 outlays by $360 million. Would you please comment on the ramifications of these proposed reductions to commercial aeronautics research and development and Space Shuttle accounts?

Answer 3: Such a funding reduction would have a severe impact on NASA's Shuttle and Aeronautics programs.

The CBO proposes a reduction in NASA's operational budget for Space Shuttle, slowing the planned increase in flight rate, and saving $200 million in outlays which equates to $260 million in budget authority in FY 1986, with further savings in the outyears. Space Shuttle Operations involves a large amount of relatively fixed costs necessary to sustain the capability to conduct the planned schedule. Once this capability is funded, the cost of conducting a few additional missions is relatively small.

The NASA budget provides for a phased buildup of Shuttle production and operational activity to a rate of 24 missions per year, consistent with the projected needs of NASA, the Department of Defense and foreign and commercial users. Since both the DOD and the foreign and commercial users pay more than the marginal cost of conducting additional missions, a reduction in their flights would increase rather than decrease the required funding by NASA. The NASA budget could be reduced only by reducing NASA missions, with a severe impact on an already approved program. Furthermore, because activities in support of near-term missions are already in progress, the FY 1986 funding reductions which could be made by reducing missions are less than the $260 million in budget authority indicated by the Congressional Budget Office.

CBO contends that NASA devotes $400 million per year to "commercially oriented aeronautical research and development programs" and proposes a reduction of $160 million in outlays for the aeronautics programs in FY 1986 which equates to a reduction in FY 1986 of $360 million in budget authority. This reduction would be almost 60 percent of NASA's entire aeronautics program and would nearly destroy NASA's research and technology capability. NASA's aeronautical research program is applicable to both military and civil aeronautics technology, ad confirmed by GAO and OSTP, and it is necessary to maintain a thrust in all disciplines. Thus, such a reduction would seriously reduce the research technology base neceessary to continue the United States as the leader in military aircraft superiority and worldwide sales of aerospace equipment and technology.

Question 4: With the exception of the proposed FY 1985 rescission and supplemental submitted with the FY 1986 budget request, does NASA anticipate any additional supplementals in FY 1985?

Answer 4: NASA does not anticipate any additional supplementals in FY 1985 beside that identified in the FY 1985 pay raise.

Question 5: Based on your preliminary assessment of the recently discovered problems with the development of the Centaur G and G Prime Upper Stage, will NASA be able to cover the FY 1985 cost overruns with available contingency funds? How large of an overrun are we discussing? What is the estimated cost to NASA? What is the estimated cost to the Air Force? Will the Air Force be able to offset its share of the cost overruns with available contingencies as well as stay within their development cost cap of $150 million? If the Air Force cap would be exceeded, would NASA be required to pick up the additional costs? Will there be any possible schedule disruption to the Galileo and Ulysses launches as a result of this development?

Answer 5: The amount of the cost increase and the cost to NASA and the Air Force are being assessed by a joint NASA/USAF team and the NASA results will be available by April 1, 1985. We assume that the Air Force results, against their budget, will be available in a similar time frame. It should be emphasized that these cost increases are associated with the completion of development and the fabrication of the first four flight articles. Two of these are NASA (for Galileo and Ulysses) and two are Air Force flight units. These results will determine if NASA and the Air Force can offset these increases within their available budgets. The MOA with the Air Force contains a cap of $150 million on development costs, and under the terms of the original agreement, NASA will be responsible for any development costs which exceed that cap.

This increased cost is partially the result of additional test effort and overtime in order to maintain the Galileo and Ulysses schedules. We remain confident that these launches will be achieved on schedule.

Controversial Subjects Omitted From Statement

Realizing that OMB clears all testimony, it is not surprising to see certain issues not included in your prepared testimony. However, I would like to have your position for the record on the three relevant issues:

1. Shuttle Pricing Policy,

2. The Complementary Expendable Launch Vehicle (ELV); and,

3. Air Force and NOAA's use of Titan IIs.

Shuttle Pricing Policy

Question 7: Would you please give the Committee your views on Shuttle pricing policy and the process being used to formulate the post-1988 Shuttle pricing options for the President?

Answer 7: The original objectives of the Shuttle pricing policy was to recover from all customers full operational costs over a specific period. This full cost recovery objective was altered somewhat when the price for the second phase of Shuttle operations was established in

1981.

The objectives for the second phase pricing period (FY 1986 through FY 1988) were to reduce the additional burden to the U.S. taxpayer for foreign and commercial flights, to remain competitive and to have foreign and commercial customers contribute to the reduction of fixed costs to fly U.S. government launches. This price was defined as "out-of-pocket" costs which was about 40 percent above marginal (additive or incremental) projected costs. The intent was to allow the Shuttle to gain additional experience in operations and cost in order to use a pro rata share of full costs as the basis for price.

The Administration, through NSDD 144, directed NASA to submit to the Senior Interagency Group (SIG) Space a plan to recover full costs for foreign and commercial Shuttle operations commencing in FY 1989. A plan has been submitted to SIG Space by NASA.

Question 8: What are the consequences of and the reasons for the recent decision to let Space SIG and not the Cabinet Council make the final recommendations to the President?

Answer 8: In our opinion, the assignment to SIG Space is appropriate since the decisions impact many national security issues. The Cabinet Council on Commerce and Trade Commercial Space Working Group will review the information prior to submission to SIG Space and the Cabinet Council on Commerce and Trade will be briefed on the results of this effort.

Question 9: In your opinion, are the "real" policy issues receiving the necessary attention or is this an interagency brouhaha?

Answer 9: The policy issues include this Nation's leadership in space,Federal role in national security issues and the balance of trade. These issues are being broadly discussed in both the executive and legislative branches.

Question 10: One of the factors in the Shuttle pricing policy debate is the Shuttle flight rate.

Will you please inform the Committee as to how many Shuttle payloads can be identified at present for the FY 1987, FY 1988, and FY 1989 Shuttle manifest?

Answer 10: The following table, compiled from the most recent Space Shuttle manifest plan, illustrates the payloads by customer category for the Fiscal Years 1987, 1988 and 1989:

* * * * * * * * * * * * * FY 1987 * * * * * * * * * * * * * *

NASA	COM'L/FOREIGN	DEPT OF DEF
Mat'l Science Lab-5	GSTAR-C	DOD 87-1
ASTRO-2	SKYNET-4B	DOD PAM-2
SPARTAN-3	STC DBS-B	DOD PAM-3
Mat'l Science Lab-6	INTELSAT VI-2	DOD PAM-4
LDEF-2	SATCOM KU-4	DOD PAM-5
Life Science S/L-2	INTELSAT VI-3	DOD PAM-6
Mat'l Science Lab-7		DOD 87-2
SUNLAB-1		DOD PAM-7
Mat'l Science Lab-8		DOD PAM-8
Int. Mat'l Lab-1		DOD 87-3
OAST-3		
Chem Release/Radiation Exp		
ASTRO-3		
Mat'l Science Lab-9		
SUNLAB-2		
ROSAT (Co-op mission)		

* * * * * * * * * * * * * FY 1988 * * * * * * * * * * * * *

NASA	COM'L/FOREIGN	DEPT OF DEF
Mat'l Science Lab-10	INTELSAT VI-4	DOD 88-1
LAGEOS-2	RCA DBS-4	DOD PAM-9
Earth Obs Mission-3	SBS-6	DOD PAM-10
Tethered Sat-1	*STC DBS-D	DOD PAM-11
*CMFM-1	*ORION-A	*DOD 88-2
*Life Science S/L-3	*C2-SPACELINES	*DOD PAM-12
*Gamma-Ray Obs	*STC DBS-E	*DOD PAM-13
*Mat'l Science Lab-11	*CBSC-1	*DOD 88-3
*COBE	*ORION-B	*DOD PAM-14
*Mat'l Science Lab-12	*SPACELAB-J	*DOD PAM-15
*Venus Radar Mapper	*WESTAR-8	*DOD PAM-16
*CFMF-2	*STC DBS-F	*DOD 88-4
*SP PLASMA-1	*EURECA	*DOD 88-5
*LEASECRAFT-101	*UNISAT-1	*DOD PAM-17
*Mat'l Science Lab-13	*WESTAR-A	
	*ORION-C	
	*RCA DBS-5	
	*STC DBS-C	
	*TELESAT-K	
	*UNISAT-2	
	*ITALSAT-1	
	*TELSTAR-3B	
	*USSB-A	
	*WESTAR-B	
	*ORION-D	
	*SBTS-A3	
	*SPACENET-D	
	*UNISAT-3	
	*RCA DBS-2	
	*CBSC-2	
	*EURECA-retr.	

*USSB-B

*Payloads reservations booked but not firm.

* * * * * * FY 1989 (All reserved but not firm) * * * *

NASA	COM'L/FOREIGN	DEPT OF DEF
Earth Obs Mission-4	SPACELAB-D4	DOD PAM-18
SHEAL-2	GALAXY KU-2	DOD PAM-19
Mat'l Science Lab-14	FORDSAT-1	DOD 89-1
EUVE	WESTAR-9	DOD 89-2
OSTA-9	WESTAR-C	DOD 89-3
CFMF-3	FORDSAT-2	DOD PAM-20
Int Mat'l Lab-2	INTELSAT VI-5	DOD PAM-21
Mat'l Science Lab-15	FORDSAT-3	DOD 89-4
LEASECRAFT-retr.	INTELSAT VI-6	DOD PAM-22
Mat'l Science Lab-16	TELESAT-L	DOD 89-5
SUNLAB-3	RCA DBS-1	DOD 89-6
Mat'l Science Lab-17	SBTS-A4	DOD 89-7
LDEF-2 retr.		
MAST-1		
Mat'l Science Lab-18		
SHEAL-3		
LEASECRAFT-102		
SP PLASMA-2		
ACTS		
Mat'l Science Lab-19		
Life Science S/L-4		

Question 11: What factors would lead the Committee to believe that a 24 flight per year rate of operation, not a capability rate, is plausible in light of the "soft" communications satellite launch market, the loss of DOD and NOAA payloads, and the minimal short-term demands of commercial space firms?

Answer 11: The President recently approved a NASA/DOD agreement in which DOD agreed to utilize at least one-third of the STS flight rate capability targeted at 24 flights per year. The NASA scientific requirements plus increasing Space Station requirements beginning early in the 1990's will require another third of the 24 per year flight rate capability. The total worldwide foreign and commercial communications satellite demand is estimated to be six to eight equivalent Shuttle flights per year. At full cost pricing, the STS should capture 50 percent or more of this market, the remaining flights will undoubtedly be used up by SDI and space processing requirements.

Complementary ELV

Question 12: Would you indicate whether or not NASA has received a fair hearing on this matter?

Does the fact that your proposal is still being assessed by the Air Force mean a NASA/Air Force agreement would comply with existing procurement laws?

Will the future heavy lift requirements of NASA and DOD be a factor in the Air Force's final determination?

What are the reasons why the Air Force requires a complementary ELV?

Does the request for 10 vehicles to be launched during the 1988-1993 timeframe represent the end of this matter or will the Air Force continue to require this "complementary" capacity after 1993?

Answer 12: These issues are mooted by the recent actions whereby NASA and the Air Force have agreed on CELV and future Shuttle usage.

Question 13: What is the effect of this activity on the Shuttle manifest?

Answer 13: The use of ELVs by DOD will have the impact of reducing the DOD utilization of the Shuttle by about two flights per year, it should be noted that the recent NASA/DOD agreement signed by the President limits the DOD to the use of ten vehicles; it also states that DOD will commit to an average of at least one-third of the STS capability per year.

TITAN IIs

The Air Force recently obtained approval to use surplus Titan II ICBMs as expendable launch vehicles for the Defense Meteorological Satellite Program (DMSP) and for the NOAA-K, L, and M Polar Orbiting Meteorological Satellites.

Question 14: What were the factors that lead to this decision?

Answer 14: In response to the Department of Commerce (DOC) National Oceanic and Atmospheric Administration, NASA's letter of September 9, 1984, NASA offered launch support for NOAA Polar Weather Satellites from the Vandenberg Launch Site in the 1990 time period, using the Space Shuttle. This offer is consistent with the President's directive National Security Decision Directive 144 (NSDD-144) which provided that the Space Transportation System (Shuttle) will be the "primary space launch system for both National Security and civil government missions, and that "the STS Program will receive sustained commitments by all affected departments and agencies."

Prior to our letter of September 9, 1984, a letter from the Department of Commerce to the DOD, dated August 3, 1984, strongly supported the use of surplus Titan II Expendable Launch Vehicles for use of Defense Meteorological Satellites, and the Department of Commerces' NOAA-K, L, and M satellites. We understand that a proposal to use Titan IIs to launch the NOAA-K, L, and M Polar Orbiting Satellites is in the FY 1986 Budget for the DOD and the Department of Commerce, and that launch costs and costs to mod the spacecraft, were two items which have been discussed.

It is NASA's policy to encourage the use of shared payloads at WTR. The NASA program officies have committed to manifest compatible payloads and assign appropriate non-orbit sensitive payloads, such as microgravity research experiments, to maximize utilization of shared WTR launches.

These payloads could be accommodated on standard Shuttle launches within the projected Shuttle flight rate of 20 ETR and 4 VAFB launches per year. Such Shuttle flights could be shared flights where the satellites are flown with each other, or with other payloads.

Question 15: What consequences will it have on the Shuttle manifest?

Answer 15: Overall, the decision by the Air Force represents the potential loss of approximately one-half to one equivalent Shuttle flight per year from the Vandenberg launch site. The assessment of the problem is a matter of attempting to determine firm mission schedules for years in advance of launch, which is difficult to predict.

Question 16: Could you please give the Committee NASA's comparison of the costs between the use of the Shuttle or Titan IIs to launch these payloads?

Answer 16: Our understanding is that DOD plans to refurbish Titan II intercontinental ballistic missiles on launch vehicles for 15 to 17 satellites including three NOAA, six DMSP and six to eight other payloads from Vandenberg. We have developed a range of optimistic conservative "cost to the government" estimates for this total program considering the potential for manifesting these payloads with other VAFB payloads on the Shuttle, varying estimates, Titan II launch costs and spacecraft modification costs. These cost estimates, RY dollars for launches during the 1990's are:

	TITAN II	Shared Shuttle Flights
17 Launches	340-646	272-425
Nonrecur.Vech.	100	-
Space. Mods	16	30
Total	456-762	302-455

Question 17: How many Titan IIs will be reconfigured as ELVs?

Answer 17: We understand that 52 Titan II vehicles will be deactivated by the DOD with a group of up to 17 be modified for use as expendable launch vehicles.

Question 18: Does each Titan II launch represent the loss of an additional Shuttle payload?

Answer 18: Each Titan II launch represents the loss of approximately one-half to one equivalent Shuttle flights from Vandenberg. Each Titan II launch represents a lost of potential opportunity for more efficient manifesting of STS operations since each one could be launched as a shared STS payload.

Question 19: Has this been factored into the manifest?

Answer 19: None of the payloads proposed for Titan II launches are presently manifested on the Shuttle.

Space Station Issues

Question 20: Could you please give the Committee an indication of why NASA is reluctant to establish a target date for the Initial Operating Capability (IOC) of the Space Station?

Answer 20: NASA wants to be sure that when a date for IOC is set, it is a date we are in a position to meet. We will be better able to give a hard date for IOC upon completion of our definition studies. This extensive analysis is the only way we know to achieve not only schedule but also cost and technical estimates upon which we all can rely.

Question 21: Doesn't this further complicate planning, program development and budgeting activities?

Answer 21: As we stated, we have deferred firm schedules deliberately to allow thorough program definition that is really needed in large programs like Space Station. The Space Station philosophy is to produce firm numbers and schedules that are credible. Thus a specific date for IOC has not been set at this time.

Question 22: You have testified on several occasions that a Space Station can be bought "by the yard." Does this mean that the $8 billion cost estimate for the Space Station is the ceiling?

Answer 22: The $8 billion estimate was the most accurate estimate of design and development costs currently available. The $8 billion cost estimate for the design and development of the Space Station was the result of an intensive effort by the Space Station Task Force's Concept Development Group (CDG). The CDG utilized the Space Station Cost Model, developed by the Marshall Space Flight Center, to perform both parametric cost estimates and cost trade studies of a variety of manned Space

Station candidate concepts. The definition contracts, starting on April 1, 1985, will provide us with additional cost data which will enable us to refine our current estimates and establish the baseline configuration and capabilities of the Station.

Question 23: Would you please give the Committee the projected budget for the Space Station for the next five years?

Answer 23: The projected budget for the Space Station for the next five years is as follows:

(Real year million of dollars)

FY 1986	FY 1987	FY 1988	FY 1989	FY 1990
$230.0	$580.0	$1050.0	$2070.0	$2270.0

Question 24: Could you please give the Committee your view of what components the IOC configuration will consist?

Answer 24: We have not yet made a decision on exactly what components will make up the IOC Space Station. Determination of these will be a major part of the Space Station definition and preliminary design effort which is due to begin in April of this year.

In the package soliciting industrial proposals for participation in the Space Station definition and preliminary design phase, we included a reference configuration to serve as a basis for the evaluation of responses submitted by the offerers. The reference configuration did offer a set of IOC components. It was comprised of two habitability modules, two laboratory modules, two resupply modules (one in orbit, one in process on the ground), a resource system, and two platforms (one co-orbiting with the Space Station and one in polar orbit).

Question 25: Will any of these components be supplied by our foreign partners?

Answer 25: Although a number of Space Station elements are under consideration by potential partners as candidates for cooperation, the identification of specific components to be designed and developed by international partners will be determined during definition in conjunction with the finalization of the baseline configuration for the IOC Space Station.

Question 26: Is a polar orbiter part of the IOC?

Answer 26: We have not yet made a final decision on what components make up the IOC Space Station. However, we have included an unmanned polar orbiter as part of the $8 billion Space Station reference configuration in our definition and preliminary design effort.

Question 27: At a recent House Science and Technology

Committee Hearing, a NASA witness indicated that it would take 7 Shuttle missions over a period of 9-12 months to achieve IOC.

a. Are the costs of these dedicated Shuttle flights included in the $8 billion Space Station cost estimate?

b. Will our foreign partners be required to use the Shuttle as the "primary" transportation mode to the Space Station?

c. Will our foreign partners be required to pay the prevailing "Shuttle price" or will they get preferential pricing treatment?

Answer 27:

a. The $8 billion Space Station cost estimate (FY 1984 dollars) was the estimate of the costs required to define, design, and develop a permanently manned Space Station. The costs required to launch the Space Station elements are not included in this estimate.

b. Economic considerations will likely cause NASA's foreign partners to use the Shuttle as their primary Space Station transportation mode--at least for the initial period. However, we do not require that they use the Shuttle if they develop their own transportation system to be compatible with the Station.

c. NASA has not yet begun negotiations with our foreign partners to determine the quid-pro-quos for cooperation in the development, operation and utilization phases of the Space Station program.

Question 28: As is the case whenever a major new endeavor is undertaken, one expects technological breakthroughs or advances that spinoff into other sectors of the economy.

a. Will the Space Station transcend existing technological standards or is it "off-the-shelf" technology?

b. Can NASA provide any data to the Committee that evidences the benefits or rate of return anticipated from the R&D investment being made to develop the Space Station?

Answer 28:

a. In order to provide improved efficiency and effectiveness in the initial and a future evolutionary Space Station Design, we are developing and demonstrating new high leverage technologies where "off-the-shelf" capability is insufficient. The Advanced Development Program was established to accelerate the maturity of selected new technologies to quantify performance and evaluate risk in a ground-based environment. This program includes both the establishment of test beds and related facilities as the ground-based evaluations media and preparation of advanced technology hardware and software for developmental testing. These technology demonstrations are planned on a schedule that will take the risk out of the hardware development phase.

NASA believes that technologies developed for the Space Station will find their way into other sectors, although the process may not be direct or immediate.

b. Several studies have been done attempting to identify and measure that portion of economic growth attributable to technological progress due to the space program.

These studies utilized various econometric models and various assumptions had to be made. But the important point to derive from these studies is that the dollar invested by NASA is returned many fold to the economy of the United States.

Aeronautics

Question 29: Last year, NASA joined the Federal Aviation Administration in the Controlled Impact Demonstration (CID) project in which a B-720 aircraft was crash-landed. NASA's primary interest was in the structural crashworthiness aspects of that project.

Would you please outline for the Committee NASA's specific objectives in the CID and the results you have obtained?

Answer 29: NASA's primary responsibilities for this program included the following:

1. Development of a remotely piloted vehicle (RPV) system to fly the aircraft using a ground-based pilot.

2. Development of a 350-channel data acquisition system and associated instrumentation for the aircraft to measure impact dynamic loads and motions during the impact.

3. Development of aircraft analytical models for predicting the structural response and load transmission path throughout the aircraft structure at impact.

During the experiment on December 1, 1985, the CID aircraft was successfully flown to the impact site using the RPV system. Impact dynamics data from 97 percent of the instrumentation data channels were successfully obtained and all onboard cameras functioned properly with the resulting film being used to document interior impact response and subsequent fire/smoke build-up in the cabin area. All measured dynamic loads data are being analyzed and correlated with predictions. NASA plans to hold a workshop on April 10, 1985, to present CID structural dynamic results to industry.

Question 30: The Committee has heard that NASA's planned 1987 flight test of the single-rotation Advanced Turboprop (ATP) may be overtaken by industry efforts to test a counter-rotational turboprop.

Do you believe that private industry has a sufficient technological data base to carry this program to implementation without the 1987 NASA flight test? Is it appropriate for NASA to continue to take the lead on the ATP program, given the accelerated efforts of the manufacturing industry?

Answer 30: NASA believes that the planned FY 1987 NASA flight test is a necessary part of a broad based, multi-element technology program that addresses the key issues that are important to all propeller/airframe installations that the industry is considering. The flight test of a large-scale, single-rotation propeller is addressing questions of aeroelastic performance and acoustics which cannot be adequately verified in small-scale model testing. This flight test data will be used to provide the scaling verification for structures and acoustics analytical predictive techniques which are applicable to all ATP configurations including counter-rotation.

NASA still has the lead role in developing a generic research and technology base in ATP performance, structures and acoustics. The industry is concentrating, as they should, on specific concepts and configurations that it feels will be viable for products in the early 1990's and is pursuing near-term flight demonstrations to confirm their performance potential. However, until the technology base is completed and verified for various propeller and drive system configurations along with the related aircraft technologies, it is not clear which configuration(s) will yield the most potential for and future product development.

Only one-half of the NASA ATP program in FY 1986 is dedicated to the flight test activity. The program is also addressing cabin acoustics, gearbox technology, installed performance and counter-rotation technology. NASA is pursuing counter-rotation technology through a series of model tests at General Electric and Hamilton Standard, as well as providing approximately 50 percent of the support for the large-scale Unducted Fan (UDF) proof-of-concept test. NASA and General Electric are also negotiating the use of Government-owned F404 engines for the referenced industry counter-rotation flight test. In return, NASA would receive access to the data acquired during the tests.

Question 31: The President's budget for FY 1986 proposes the elimination of NASA's advanced composite program.

Without continued support for the developing technology by NASA, is the available data base sufficient to ensure continued development and implementation by the aircraft manufacturing industry? If not, how will termination of this program affect the future competitive position of the U.S. aircraft manufacturing industry, with respect to the use of composites?

Answer 31: It is NASA's belief that the composite secondary and medium primary structures program, now being completed, will provide a sufficiently broad data base for industry to move into composite primary structures. In addition, NASA's R&T base program will continue to provide support for fundamental composites research and technology. It is our plan to obtain the maximum benefits in advancing composites technology by restructuring the current Advanced Composite Structures Technology (ACST) program within the limits of the remaining FY 1985 funds. We also plan to reassess the NASA R&T base composite programs to develop a viable research plan that will enable efficient utilization of composite materials for advanced structural concepts. This action will involve interaction with industry in order to establish an appropriate program content and timeframe for our future plans.

Question 32: Would you please give the Committee an update on the activities of the NASA Task Force on the Commercial Use of Space? What recommendations, if any, has this group made? Will legislative changes or procurement law changes be required to facilitate the commercial use of space?

Answer 32: The NASA Advisory Council Task Force on the Commercail Use of Space will counsel NASA on the development of the appropriate policies, programs, and research priorities to foster the commercial use of space and the conduct of these programs. Currently in the fact finding phase, the Task Force is reviewing:

- National Policy and NASA Objectives
- Opportunities to Work in Space on the Shuttle, Spacelab
- Current Views on Commercial Opportunities in Communications, Remote Sensing, and Materials Processing
- Research on Materials Processing and Microgravity
- NASA's Investment Strategy, Planning Process, and Advisory Structure
- Process for Negotiating Research Agreements, Planning Flight Opportunities and Missions, and Integration of Experiments into the Orbiter

The Task Force on the Commercial Use of Space has not as yet made formal recommendations on these issues. NASA is trying to identify those laws which may need to be changed in order to facilitate the commercial use of space.

Question 33: The RFP for the Mars Geoscience climatology Orbiter that will be released in May of this year will represent a significant effort on the part of NASA to properly assess "commercial proposals."

Answer 33: Existing procurement statutes do not provide for giving preferential treatment to a class of offerors. The only form of preference that presently exists is essentially directed to labor surplus area firms and small disadvantaged businesses. Therefore, the Source Evaluation Board process at NASA (and selection process at JPL, which is conducting the procurement for the Mars Observer,) contemplates a thorough appraisal of offers based on the probability of quality performance, timely performance, realistic cost estimating and pricing, logic of proposed performance, and management of projects. Selection criteria, in our judgment, must be chosen carefully enough to apply equally to all offerors and support free and open competition in regard to the technical requirements. NASA will use the government procurement process within the context of the foregoing criteria, and other relevant criteria, to encourage private investment in space.

Space Science and Applications

Question 34: There are no new starts for Space Science and Applications in the NASA FY 1986 Budget Request. While it is dtrue that FY 1986 is a banner year for space science and applications, there is concern about the future of space science.

a. Would you please inform the Committee why there are no new starts for Space Science and Applications in the FY 1986 Budget Request?

b. What new Space Science and Applications starts should the Committee expect to receive in FY 1987?

c. What is the order of priority for the programs currently lined up at the starting gate? (AXAF, SIRTF, RAF, SOT, GP-B, ISTP, and TOPEX). Does the lack of "new start" status in FY 1986 sound the death knell for TOPEX and ISTP?

d. Could you please give the Committee an indication of what the new start planning wedge is for FY 1987,dFY 1988, and FY 1989? How does this compare with last year's estimate? What percentage of this wedge will be allotted to Space Science and Applications?

Answer 34:

a. No new starts were included in the FY 1986 budget request in support of the President's desire to initiate the Space Station and continue a balanced space program.

b. The Space Science and Applications missions that are currently under study as possible candidate FY 1987 new initiatives include AXAF, CRAF, GP-B, ISTP, and TOPEX.

c. The candidate FY 1987 new starts have not yet been prioritized. Over the next several months, as part of our FY 1987 budget formulation process, we will review the inputs from our various advisory committees, dthe science community, and our internal science managers to determine our recommended priorities for FY 1987. We do not believe that the lack of new starts in FY 1986 will adversely effect how TOPEX and ISTP are preceived as candidate FY 1987 new initiatives.

The Solar Optical Telescope (SOT), is included as part of the Spacelab program.

d. A modest new start "wedge" for FY 1987, 1988, and 1989 is maintained by the agency management to support future missions. The amount of the wedge fluctuates as new liens become apprarent or existing plans are altered which releases the previously encumbered amounts. Because of the volatility, none of the wedge funding is made available to the program offices such as OSSA until the overall NASA budget is formulated and decisions are made on the relative priorities from an agency standpoint.

International Cooperation

Question 35: There has been much written lately about a "cooperative space venture" with the USSR. Is there any validity to these rumors, and would you please describe NASA's current role in this activity, if any?

Answer 35: The United States proposed last year that a joint US/USSR simulated space rescue mission be undertaken in which astronauts and cosmonauts would develop techniques of potential use in space emergencies. The Soviets have not, thus far, indicated any interest in substantive discussions of the U.S. proposal. There have been proposals advanced by private groups, and also in a pending Senate resolution, for cooperation in Mars exploration, with an eye perhaps to a joint manned mission. As the President stated on October 30, 1984, "...we are prepared to work with the Soviets on cooperation in space in programs which are mutually beneficial and productive."

Question 36: What initiatves are likely "candidate missions" for a joint U.S./USSR mission?

Answer 36: NASA has considered a variety of candidate Shuttle flights for this purpose, but for the time being, no decisions have been made. Assuming the Soviets accept the U.S. offer in the future, this would be a subject for joint negotiation.

Question 37: Has the USSR supplied NASA with digital tapes and data from the VENERA mission?

Answer 37: There has been a long history of US/USSR cooperation in the exploration of Venus. Recently, a university scientist whose work NASA funds received a magnetic tape containing digital data sets from previous Soviet Venera lander missions, and these data are currently being analyzed.

Question 38: To what extent are the U.S. and USSR cooperating in civilian space activities at the present?

Answer 38: NASA is currently supporting scientist-to-scientist contacts and data exchanges with Soviet counterparts in the life sciences and in planetary research. In addition, a U.S. experiment will be flown on the next Soviet biosatellite mission to be launched this summer. There are also several multi-lateral cooperative activities underway which include U.S. and Soviet participation, such as the Inter-Agency Counsultative Group (IACG) on Halley's Comet and the COSPAS-SARSAT satellite search and rescue system. We remain interested in further broadening our cooperative activities to other mutually-beneficial areas.

Fifth Orbiter

Question 39: For the past several years, the Congress has supported the production of a fifth orbiter. To secure this option a significant level of support has been given to the orbiter structural spares program.

a. To maintain the fifth Orbiter production option, what level of funding would be required (assume a 1991, a 1992, and a 1993 delivery date?) Would any additional funds be required in FY 1986?

b. If the current production line is shut down and a fifth Orbiter is eventually required, what will the additional start up costs be? What will the total estimated cost of a fifth Orbiter be (assume a 1992, 1996, or year 2000 decision to proceed)?

c. At what point in time will NASA commence the development of the advanced Shuttle -- Shuttle II? How does this timing influence the decision to procure a fifth Orbiter.

Answer 39:

a. To maintain the fifth Orbiter production option, the level of funding in the FY 1986 budget, regardless of OV-105 delivery dates, would be the currently funded structural spares and logistics programs. We believe that with the requested funding level, the production capability is maintained through FY 1986, with minimal loss of critical skills. No additional funding is required through FY 1986 for a 1991 or later delivery of OV-105.

b. If the current Orbiter production line is shut down and a fifth Orbiter is eventually required, the additional start-up costs for a 1992 build will be determined by many factors which are difficult to quantify. These factors include when the decision is made, the condition of tooling at the time, what facilities are still available, and others. By the year 1996 or 2000, the Agency anticipates that a second generation shuttle might be an active program, precluding the need for additional Orbiters.

c. NASA anticipates initiating an advanced Shuttle program in the early to middle 1990's. With an early 1990's start, a Shuttle II would be operational about the turn of the century.

Question 40: Is it wise to expect to rely upon a four Orbiter fleet for 20 years? What if there were an accident? What if the shuttle required further modifications in order to accommodate future mssions, payloads, or operational requirements -- not an unlikely assumption for a 20-year period? Is a four Orbiter fleet capable of servicing a Space Station, launching projected payloads, and servicing future commercial customers?

Answer 40: The Shuttle fleet size has been determined by the current and long-term (through the late eighties and early nineties) launch requirements as now known. The structural spares program maintains the Orbiter production capability and minimizes the time required to procure a fifth orbiter or repair a damaged Orbiter.

The Agency is continuously projecting launch requirements for the next 6 to 8 years and will, if and when necessary, propose the timing of an enlarged Orbiter fleet and associated ground facilities to accommodate those projections. If an Orbiter was taken out of operational status for extensive modifications, the operational planning could go to a "surge" mode for a limited period of time (i.e., 7 days per week, 3 shifts per day), such that the remaining three Orbiters could accommodate the launch requirements for the near term.

A four Orbiter fleet will be capable of launching 24 flights a year with a short-term surge capability to about a 28-flight per year rate. Launch projections for the Space Station's utilization are not defined well enough at this time to estimate whether four Orbiters will be capable of supporting Space Station, other government payloads, and the commercial industry. The launch requirements for space station are expected to harden during the Phase "B" studies. These requirements will be timely in the decision process for a possible fifth Orbiter.

QUESTIONS OF SENATOR INOUYE AND THE ANSWERS
Space Science and Applications

Question 1: The proposed budget does not allow for new Space Science and Applications starts on Topex (the ocean topography experiment) or an STS demonstration of the Gravity Probe B Experiment. What is now the Agency's plan for initiating these programs in later years? How does this affect the schedule for new starts on other missions; particularly Advanced X-Ray Astrophysics Facility, Space Infrared Telescope Facility and a cometary rendezvous mission?

Answer 1: The Topex and GP-B are among the important science and applications missions that are currently under study. The appropriate advanced technology development is underway to ensure our readiness to perform the missions when budgetary conditions permit.

We are currently in the process of formulating the FY 1987 budget, and during this period all of our requirements are being rigorously reviewed. We will consider the input from our various advisory committees, the science community, and our internal science managers in the formulation of our budget, and the establishment of our priorities for FY 1987. The budget will come together in the next several months and the mission priorities will be developed. The pace of new starts will depend on factors such as the U.S. economy, federal fiscal policies, overall Agency priorities, etc.

Question 2: The proposed FY 1986 Advanced Technology Development budget item specifies major emphasis on "Advanced X-Ray Astrophysics Facility definition as well as continued technological preparation for Space Infrared Telescope Facility." In light of the potential schedule impact of the FY 1986 new start embargo, what is the Agency's plan to take advantage of this new opportunity to continue innovative technology development related to these missions? Is similar development related to upgrading of Hubble Space Telescope specifically identified elsewhere in the budget (perhaps in Hubble Space Telescope Maintenance and Refurbishment)?

Answer: NASA plans to continue advanced technology development activities during FY 1985-1986 on both Advanced X-Ray Astrophysics Facility and Space Infrared Telescope Facility.

With regard to the Hubble Space Telescope (HST), the HST Operations funding line within Physics and Astronomy Mission Operations and Data Analysis provides for the development of second generation instrumentation for Hubble Space Telescope which will, of course, utilize any advanced technology that is appropriate.

Question 3: The proposed FY 1986 budget included items for: (1) Research and Analysis; (2) the Graduate Student Researcher Program; and (3) frequent, low-cost flight opportunities such as those provided by the Spartan, Get-Away Special and Hitchhiker programs. Are these adequate to nourish university graduate student programs in space science at a level which will ensure an adequate mix of first-rank space science research talent in the coming decades.

Answer 3: The Office of Space Science and Applications (OSSA) has maintained a close relationship with the academic community since OSSA's inception. Our funding support has been fairly constant at about 12-14 percent of the total OSSA budget.

As a result of the varied nature of OSSA's activities, the academic community is involved in a wide range of space-related work. University scientists and their students participate in the flight programs on satellite instrument teams, on observing with spaceborne facilities, and in the Research and Analysis (R&A) programs through unsolicited proposals, applications notices and announcements of opportunity. Many investigators invite graduate students at their home institutions to participate in their discipline research. This research is supported by the funds received from NASA. It is normal occurrence that at least one and often several graduate students are supported by each university grant or contract issued by NASA. This involves several hundred graduate students each year.

In addition to the university investigation funded directly by OSSA, funding for the Graduate Student Researchers Program was increased this year to initiate 40 new fellowships to graduate students pursuing M.S. and Ph.D.'s in disciplines related to the space sciences. It is planned that this program will grow to a steady state number of 120 students receiving support in 1987. Under this program, graduate students are supported to carry out a program of study or research at their home institution. Another component of the Graduate Student Researchers Program, which was initiated 1980, provides 40 new awards each year to support graduate study or research that is of interest to the mission of our field centers. Currently, 120 students are being supported through our field centers and it is estimated that approximately 50 percent of those awards are in support of OSS related programs. In summary, NASA's Graduate Student Researchers Program's objective is to attract top U.S. graduate students, sponsoring their activities at a critical time in their education and reaffirming NASA's commitment to graduate study. In total, therefore, NASA is supporting aproximately 160 graduate students in FY 1985 and plans to support 240 graduate students per year by FY 1987.

Postdoctoral resident Research Associateships are funded under the Office of Space Science and Applications and Research and Analysis (R&A) programs through participating NASA field centers. These postdoctoral positions are supplemented by visiting scientist postdoctoral appointments under the Universities Space Research Association (USRA).

Senator GORTON. Mr. Moore, as is the case is with Mr. Beggs, your entire written statement will be included in the record as if read. We would appreciate a summary.

STATEMENT OF JESSE W. MOORE, ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. MOORE. With your permission I would like to read a short prepared statement prior to answering questions before the committee.

Mr. Chairman and distinguished members of the subcommittee, I am pleased to appear and present the NASA budget request for fiscal year 1986 for the Office of Space Flight. Programs in the Office of Space Flight include the space shuttle, spacelab, expendable launch vehicles, various upper stages and advance programs.

Mr. Chairman, during the past year the space shuttle has continued to prove itself an extremely versatile and reliable space transportation system. With the Solar Max repair, Palapa and Westar retrievals, and the orbital refueling demonstration we have witnessed another major step in the evolution of space. We are proud that the space shuttle is a platform from which these extraordinary events have been accomplished.

As the primary space launch system for both national security and civil government missions, the President of the United States has directed that NASA's first priority is to make the space transportation system fully operational and cost effective in providing routine access to space. Our program plans and budget request for fiscal year 1986 fully support this priority.

I would like to take this opportunity to briefly discuss the highlights of the missions that are planned for fiscal 1985 and fiscal 1986. The fiscal year 1985 space shuttle mission highlights include: the retrieval of the Long Duration Exposure Facility that was launched in 1984. It includes the launch of two dedicated spacelab flights, including the initial flight of the Igloo, pallet configuration, and the very important instrument pointing system. It includes launch of two tracking and data relay satellites. It includes the first flight of the space science payload called Spartan. It will include the launch of eight commercial communications satellites, the reflight of the continuous flow electrophoresis experiment, and the first flight of the orbiter, Atlantis. We expect to take delivery of our fourth orbiter, Atlantis, in April of 1985, and its inaugural flight is planned for September of 1985.

In fiscal year 1986 pad B at the Kennedy Space Center will be brought into service to support two important planetary launches from pads A and B in May and June 1986. These are the Galileo Jupiter launch, an orbit and probe of Jupiter, and the Ulysses launch for gravity-assisted flyby of Jupiter which will observe the sun at high heliographic latitudes.

Shortly after these two launches we will launch the Hubble Space Telescope. Other missions in fiscal year 1986 include four spacelab flights, the deployment of 12 communication satellites, two flights of the McDonnell-Douglas pharmaceutical module, the initial Shuttle flight from the Vandenberg Air Force Base launch complex in California, a flight to observe Halley's Comet, and several flights for other materials processing payloads.

Our Space Shuttle Program in fiscal 1985 and 1986 continues to emphasize and focus on spares and logistics, improvements in the lifetime of the space shuttle main engine, and in other system improvements in both the orbiter and other elements of the space shuttle system. We are well on our way to a flight rate capability of 24 per year by the end of this decade with 10 missions planned for fiscal year 1985 and 14 missions planned for 1986.

I would like to point out, Mr. Chairman, that we have recently become aware that our current cost estimates for the Centaur Program are likely to increase. This is a joint program with the Department of Defense, and we require the Centaur for launch of Galileo and Ulysses. We have assigned a team to conduct a comprehensive review of the Centaur cost, and we expect their full results and report by about mid-March. Let me assure you that this effort is receiving priority attention in my office and in NASA.

Our fiscal year 1986 budget request for the Space Transportation System Program is $3.16 billion. This includes $2.7 billion for spaceflight control and data communications, and $459 million for research and development. We are pleased that our fiscal year 1986 budget request includes $25 million for initiation of the orbital maneuvering vehicle, the OMV, which is reusable, and remotely powered. This represents a significant extension of capability for the STS, as well as a very valuable space infrastructure element for the space station. With a fiscal year 1986 new start, the OMV will be available for flight use in 1990.

We are determined to continue to help this Nation provide leadership in space transportation. The STS team will continue to vigorously pursue improvements in the efficiency, reliability, and flexibility of the total space shuttle system. We look forward to a challenging and rewarding future as we fully exploit the versatile capabilities of the shuttle. With your help, Mr. Chairman, we can meet the challenges of the future.

Thank you.

We will be pleased to answer questions at this time.

Senator GORTON. On the question of a fifth orbiter, assuming that a fifth orbiter cannot be justified solely on the basis of projected shuttle demand, are there compelling reasons to justify it simply as a backup vehicle?

Mr. MOORE. Well, Mr. Chairman, if you mean in the event we would have a damaged orbiter such that we would be down for some period of time, our then fleet of three vehicles would not clearly be adequate to meet our flight rate that we are projecting by the end of this decade, around 24 flights per year.

We are, however, as you know, implementing the Structural Spares Program which was initiated back in the 1984 timeframe to provide us some protection against damage, major damage to an element of the orbiter. However, if an orbiter were down for some period of time, with a fleet of 3 we would not be able to capture the full capability of the 24 flights per year.

Senator GORTON. Could you give us some idea of the projected market for the launch of communications satellites during the course of the next decade, the percentage of that market which

NASA seeks and thinks it can handle, and its relationship to an American ELV industry?

Mr. MOORE. Well, Mr. Chairman, the communications satellite industry is, based upon our assessments of that industry, and at least over the next 5 years, and then I will talk about it a little bit further after that, we are not quite as optimistic in our assessment of that marketplace over the next 5 years as we were say a year ago or 2 years ago. We see a total launch demand on the order of 15 to 20 communications satellites per year over that 5-year period. The market beyond that, I think, in the next 5 years certainly depends upon a number of things. I think we will have to see what kinds of technological breakthroughs may occur in the satellite industry, as well as what the impacts might be of such applications as fiberoptics.

There is an activity underway now to spend some $600 million to lay some cables across the Pacific for fiberoptics transmission. It is my understanding that this will provide a capability equivalent greater than about four satellites. So, I do not know where fiberoptics is going in the long term, but that technology is certainly going to be a factor that is going to be affecting the communications satellite market.

Today there are several satellites on the market for sale, which would indicate the market may be nearing saturation with the 15 to 20 communications satellite launches per year. I do not see that rate increasing much over the next 5 years. My crystal ball is not too awfully clear beyond that 5 years, but we are continuing to do market analyses to see whether we think the market is going to go up or go down.

I think with respect to the ELV side of the house in terms of the marketplace, we can project that with the Ariane launch vehicle the French are currently flying, that by the 1986 or early 1987 timeframe, with two launch pads I think Ariane could probably capture that particular market of communications satellites.

I think also in terms of the shuttle it is our objective to capture a dominant portion of that market, but over the past 14 or 15 months we have split 5 and 5 with Ariane, so in fact, of those deals that have been consummated during the past 14 months, we are at about a 50-percent rate. It is our objective to capture more of that, and we are aggressively marketing to attempt to get a bigger share of that market.

Senator GORTON. What about U.S. ELV's?

Mr. MOORE. I think U.S. ELV's, if they are commercialized, will certainly have to be very cost competitive with Ariane. I think some of the satellites that are going to be launched during that period of time probably will exceed the Delta launch vehicle capability, so you will probably have to go up to a little larger launch vehicle like Atlas Centaur to capture some of them; and I think it is going to be very important that you have a price competitive situation. I think price is going to be the determining factor in a market that may be nearing saturation. It is very price competitive. And if the costs are in that ballpark, the American commercial ELV's, certainly could capture some of them.

What I am afraid of, however, is that the French will continue to competitively bid against any of the U.S. commercial ELV's, and traffic will be lost to the French, as opposed to staying here in the United States.

Senator GORTON. The Air Force announced plans to launch two space shuttle missions a year starting in 1987 on which SDI experiments will be conducted. How will those requirements affect the shuttle manifest, and how likely is it that SDI requirements will necessitate more than two shuttle missions a year?

Mr. MOORE. Well, we have just received a request recently, Mr. Chairman, on SDI's intention for two half bay of shuttle capability per year beginning in 1987. We have capability in our manifest and in our Shuttle Flight Program at this point in time to accommodate that kind of a flight rate requirement by SDI.

For the long term, we are working very closely with the SDI people in terms of understanding what their requirements for space shuttle usage will be as they proceed down their program. I envision it to be fairly demanding as far as shuttle flights are concerned, and we are working very closely with them to accommodate their requirements as they define them.

Senator GORTON. So much attention is being given to the commercial development of space, and in particular to such activities as material processing in space that I am concerned that through these first 15 shuttle missions there have been too few flight opportunities for microgravity experiments which will provide critical baseline data for commercial applications.

What is being done to ensure that these microgravity experiments have an adequate number of flight opportunities?

Mr. MOORE. We are working very closely with the microgravity people to be sure that we do fly several of the payloads that they have ready for flight.

Senator GORTON. What period of time?

Mr. MOORE. Next year, the next fiscal year as well as the following fiscal year we have several NASA microgravity payloads to fly, and plan on accommodating them as best we can in that period of time. We have had to make some manifest changes, as you know, during the last year which caused us to impact some NASA payloads; and materials processing, as well as the Spartan payload, was affected by the manifest recombination that we had to do last summer. We have already flown one material science payload on the space shuttle and plan to fly many more as the program matures. As our flight rate goes up, Mr. Chairman, there will be ample opportunities for material sciences flights, and we are sensitive to that and will do our best to accommodate the material sciences payloads.

Senator GORTON. Finally, can you comment on the status of the safety analyses that are being conducted to determine if additional protective shielding will be required for the Ulysses and Galileo missions which will both carry radioisotope thermoelectric generators, and also on the likelihood that radioactive material from the RTG's could spread during an accident on launch?

Mr. MOORE. Well, those two questions you asked, Mr. Chairman, are very definitely related. And as you know, the RTG's provide the primary power sources for the Galileo spacecraft, as well as the Ulysses spacecraft. We have flown RTG's—I should say multi-hundred watt RTG's—back on the Voyager spacecraft which were launched back in the 1977 timeframe. We have been working with a number of folks on this, including the developer of the spacecraft, the Jet Propulsion Laboratory, as well as the Department of Energy and our own offices in doing this analysis.

We have been supporting a kind of two-pronged approach. One is to understand what the results would be of an impact on the housing for the RTG which contains the fuel source to provide the power. There have been a number of tests that have been recently completed which indicated that the housing for the RTG would stand shocks in excess of 1,700 or 1,800 pounds per square inch, which is a very encouraging sign to us. Some early analysis had shown that the RTG housing may be susceptible to fracture at as low as 800 to 1,000 pounds per square inch. So, we have demonstrated that we have more than doubled the kind of shock effects that the RTG can withstand while maintaining an integral housing.

In addition to that, we have been doing a number of safety analyses on various elements of the shuttle, including the SRB's, the engine, the orbiter, the external tank, the Centaur and so forth to get a handle on exactly what the probability might be of a catastrophic problem on the launch pad or in flight with the Centaur. Results of these analyses, at least the preliminary results, have recently been completed. We reviewed them, and we are indicating an overall probability of an accident that would have an adverse impact on the RTG being on the order of 10 to the minus 5 kinds of a probability. We think this is much less than the probability associated with the Titan Centaur that we had during the Voyager launches; and we are hoping our analysis is going to continue in this direction so that we will feel pretty comfortable about the RTG's flying on both the Galileo spacecraft and the Ulysses spacecraft.

In addition to that, we will continue to work with the Department of Energy, and we have also performed some studies on shielding these RTG's, the concern there being to provide some shields around the RTG's so that if there were some accident, shrapnel or other types of impacts on the RTG, it would not cause a fracture of the housing.

We think the shields, based on our probability analysis, the preliminary probability analysis, will not be required. They are in fact complicating elements on the spacecraft. There are more mechanisms that have to be separated after deployment and launch. And if our probability convinces us that we really should not be overly concerned about the RTG's, then we plan to proceed without the shields on either the Galileo spacecraft or on the Ulysses spacecraft.

So that is kind of where we are. We are continuing to work on the problem, working not only, as I said, internally within the agency, but also working with the Department of Energy to get a full handle on this particular situation.

Senator GORTON. Thank you very much. I have a number of other questions which I will submit in writing. I will defer now to Senator Gore..

Senator GORE. Thank you, Mr. Chairman.

Mr. Moore, in the course of the last year there has been a lot of discussion about the shuttle facility at Vandenberg. Could you please give the committee the current status of this activity and an indication of when Vandenberg will be operational?

Mr. MOORE. Yes, sir. I went to Vandenberg in December 1984 with Under Secretary Aldridge to assess the current situation of the Vandenberg launch complex. During our assessment we both concluded that an awful lot of progress is being made at the Vandenberg launch site.

At the time we toured we had a launch date set, the first launch out of Vandenberg set for October 15, 1985. As a result of that tour and seeing that the facilities were being developed on a schedule that could support the October 1985 launch, and as well as a result of an assessment that we had recently completed on orbiter Challenger's tile problems, we determined we want to hold—Discovery, I should say, in the fleet for another couple of months, as opposed to shipping out to Vandenberg. So we in turn mutually decided that we would delay the initial flight out of Vandenberg until no earlier than January 29, 1986; so a little less than a year from now is the planned launch date for the first Vandenberg flight.

We are continuing to supply the filament-wound case elements for that initial flight out of Vandenberg. As you know, the filament-wound case will provide us another 5,000 pounds of improved performance capability, and things are going quite well as far as the filament-wound case program is concerned. As a matter of fact, Mr. Gore, this week we have the orbiter Enterprise stacked with the external tank and solid rocket boosters sitting on the launch pad at Vandenberg. We have had the oribter Enterprise out there for several months going through what we call a form fit and check function to the facilities to kind of dry run the flow of the first mission out of Vandenberg. And the Enterprise, along with its other elements, are on the launch pad at Vandenberg.

We feel very comfortable about where we are in the Vandenberg launch complex and feel very confident that we will be able to make our flight date with the Air Force announced for January 29, 1986.

Senator GORE. Do you intend to dedicate an orbiter for use at Vandenberg?

Mr. MOORE. We do not have any plans for dedicating a particular orbiter. Our philosophy has been to try to make as many of the orbiters identical as we can so that we can interchange them, and that gives us the maximum amount of fleet capability. And we will work with the Air Force on orbiter assignments and provide them an orbiter that meets their requirements. When they have a Centaur flight, for example, we will obviously provide them an orbiter with Centaur mods; and our plans are to modify two vehicles for the Centaur at this point in time. We will have an interchangeability of our vehicles which will give us some flight assignment flexibility.

Senator GORE. In light of NOAA's decision to launch NOAA K, L, and M with Titan II's, what polar orbit shuttle requirements exist for NASA?

Mr. MOORE. Well, Senator Gore, as you heard Mr. Beggs state, we are still not settled on the K, L, and M situation as far as

NASA is concerned. We certainly want to go back and work at that problem some more with NOAA.

Senator GORE. Well, let's assume for the moment that that decision sticks. Then what polar orbit requirements would there be?

Mr. MOORE. Yes, sir. From a NASA point of view the things that make sense to fly out of polar orbit are those things that are not inclination sensitive, for example, things that have requirements for low gravity materials processing experiments are examples of things that can be flown out of Vandenberg. For remote sensing experiments such as the shuttle imaging radar, the SIR-B, which we have flown twice now on this program, the west coast would be an ideal site for launching a synthetic aperture radar flight. Launching out of the west coast into polar orbit would give you a complete map of the world. We are working with our friends in Space Science and Applications in order to look at the payloads and determine which NASA payloads would make more sense to fly them out of the west coast. And obviously, as you well know, until we made a decision not to proceed, we were flying the Landsat retrieval out of the west coast, which was planned for January 1987. So polar orbiting satellites, remote sensing satellites, or low gravity missions, life sciences flights, for example, and anything requiring low gravity is pretty much independent of orbital inclination.

Senator GORE. Well, I don't want to get into this in too much detail here, but NASA has certainly spent a lot of money on the special requirements needed for missions that DOD is now pulling off, and it seems to be quite unfortunate.

Let me shift gears to the orbiter maneuvering vehicle. Is it intended to be shuttle compatible, space station compatible, or both?

Mr. MOORE. The design right now, Senator Gore, is primarily focused on being shuttle compatible. Its initial application will fly out of the shuttle. However, we are asking that the requirements for being space station compatible be considered in the Orbital Maneuvering Vehicle Program. The program that we submitted for a fiscal 1986 new start includes a singular vehicle for application and use on the Space Shuttle Program with a development start in the contract for what we call the phase C-D part of the program being released in January 1986, and an initial operational date in 1990.

We are maintaining close communications with the space station people to ensure that we do not design out potential for space station compatibility. There is some interest on the part of the space station, and it is being looked at by them at this time.

Senator GORE. The space station configuration assumes two OMV's?

Mr. MOORE. I am not aware of a commitment by the space station people that includes an orbital maneuvering vehicle. And I may be wrong on that. I think the space station people might be able to provide you with that information.

Senator GORE. Well, I guess the underlying point is, is this another example of something that is really needed for the space station being charged to another account?

Mr. MOORE. No, sir. I would strongly say that is not the case. This program was studied well before the Space Station Program got approved. The application of the orbital maneuvering vehicle essentially will extend greatly the arms of the shuttle. It will allow us to maneuver payloads up to 1,500 nautical miles above the low Earth orbit, and it will also allow us to change the plane of inclination of payloads by as much as plus or minus 8 degrees. It will also be very useful out of the Vandenberg Air Force Base complex for polar orbits that need to go up to 700 or 800 kilometers. You can deploy them or retrieve them with the orbital maneuvering vehicle, and so we see it as an extension of the shuttle capabilities. And as the space station configuration matures, I am sure there will be applications for space station utilization as well. But the basic development and the basic tie is from the Space Shuttle Program as to what our intentions are with the orbital maneuvering vehicle.

Senator GORE. All right. I have some other questions on that matter on behalf of Senator Hollings that I will submit in writing.

Let me turn to a final set of questions on the shuttle manifest problems. There has been a lot of discussion about the inability of certain types of payloads to gain access to the shuttle, and there has also been a report by the Shuttle Science Working Group that promotes more frequent flight opportunities for the science and engineering communities.

What activities are the Office of Space Flight engaged in that would ensure more frequent access to space for NASA payloads, especially small and intermediate class payloads?

Mr. MOORE. Well, we have initiated last year, Senator Gore, a program we called the Hitchhiker Program. We knew that some of our friends in the science and applications community wanted to have better access to the space shuttle such that when space was available on a flight, we could put in with very short integration time for experiments; and we initiated a program called Hitchhiker, as I said, with a version of that Hitchhiker being developed at the Marshall Spaceflight Center, and that is a Hitchhiker that has an across-the-base structure that you can mount three to four experiments on, have minimal interfaces with the orbiter, and it can be mounted very late in the integration flow. Several months before flight we can say——

Senator GORE. It is sort of like a standby ticket on the airlines?

Mr. MOORE. A standby ticket on the airlines is a good way to look at it. In addition to that, we have what I would call a sister to that hitchhiker concept which is being developed by the Goddard Space Flight Center, and it is a plate which mounts on the sill of the orbiter. It, too, has very simple interfaces with the orbiter and can carry several experiments that can be integrated and put in the shuttle bay late in the ballgame.

That is our response to our friends in the scientific community and a primary way of trying to provide them with flight opportunities. In addition to that, we have manifested over the next 5 years an average of 6 or 7 completely dedicated shuttle flights to the space science and applications community. These flights obviously consist of a number of different elements. They consist from dedicated spacelabs to what we call mixed cargo spacelabs which might be a pallet of experiments, as well as free flyers.

Senator GORE. And you do not expect them to get bumped?

Mr. MOORE. We hope they are not going to get bumped. I do not plan on them getting bumped. We are going to treat our friends in the science and applications community with appropriate priority.

Senator **Gore**. Is it true that NASA is currently considering a policy that would give priority payload status to any NASA payload that has been delayed for 6 months?

Mr. **Moore**. That is an idea that is currently being discussed between my office, as well as the Office of Space Science and Applications.

And I will tell you, Senator Gore, I am not too concerned in the future about bumping too many science and applications or other payloads. As we get our STS system capability in place, we will have the ability to accommodate some of the changes that we know we are going to have downstream. We will have four orbiters as opposed to the one or two we have been operating with. We will have three launch pads where we have had one before. That will provide us an enormous increase in flexibility so that none of our customers will have to be moved around as a result of some of the problems that we have encountered in the past.

Senator **Gore**. Thank you, Mr. Chairman.

Senator **Gorton**. Thank you, Senator, and thank you, Mr. Moore. You are most eloquent and concise witness, and you have helped us a great deal, and we are both going to submit more questions to you in writing. But thank you very much.

Mr. **Moore**. Thank you, Mr. Chairman. We appreciate it. Thank you very much.

[The statement follows:]

STATEMENT OF JESSE W. MOORE, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Distinguished Members of the Subcommittee:

It is a pleasure for me to make my initial appearance before this Committee as Associate Administrator for Space Flight. I am pleased to present the NASA budget request for FY 1986 for the Office of Space Flight.

The President has directed that NASA's first priority is to make the Space Transportation System fully operational and cost effective in providing routine access to space. He has also directed that the STS Program will receive sustained commitments by all affected departments and agencies and directed that enhancements of STS operational capability, upper stages, and efficient methods of deploying and retrieving payloads will be pursued as national requirements are defined.

The Space Shuttle continues to prove itself an extremely versatile and reliable space transportation system. Since last year's testimony, the operational capability and potential of the Shuttle have been demonstrated repeatedly.

With the repair of the Solar Max Satellite, the retrieval of the Westar and Palapa communications satellites, and the orbital refueling demonstration, we have witnessed another step in the evolution of space. We can extend the useful life of our spacecraft, correct unforeseen spacecraft problems, and reduce the risk inherent in space ventures with the unique capabilities of repair, refueling, and retrieval provided by the Space Shuttle.

As the primary space launch system for both national security and civil government missions, and, with the advent of the Space Station, it will be even more incumbent on the agency that we make it fully operational and provide routine transportation to low-Earth orbit, and that we have the ability tc place spacecraft in geosynchronous orbit on a routine basis at the lowest possible cost, as well as provide the opportunity for scientific exploration and the advancement of technology that can make all our lives on Earth better.

Our FY 1986 budget request for the Space Transportation System Program is $3.1609 billion. This includes $2.7016 billion for Space Flight, Control, and Data Communications and $459.3 million for Research and Development.

During 1986, we will launch two of our most exciting scientific missions -- Galileo and Ulysses, eleven commercial communications satellites, a commercial dedicated Spacelab flight, the Hubble Space Telescope, the Astro Pallet for Halley's Comet observations, and the first launch for the Vandenberg launch site. The Ulysses mission, previously called the International Solar Polar Mission (ISPM), will be the first mission to investigate the sun from a polar perspective. The mission, scheduled for May of 1986, will use Jupiter's gravitational effect to place the satellite in solar polar orbit. Six days later, the Galileo mission is scheduled to be launched. Its mission is to orbit planet Jupiter to study the Jovian atmosphere and moons, including deployment of an atmospheric probe.

Before turning to the details of the budget request, I would like to review a few of our major accomplishments during 1984, our plans for 1985, and report on our programs for which funds are requested in FY 1986.

STS Mission Highlights

Space Shuttle missions in FY 1984 achieved numerous milestones both commercially and in science and technology. In FY 1984 we deployed five new commercial communications satellites for Western Union, Indonesia, Satellite Business Systems, AT&T, and Hughes Communications.

Two communications satellites for Western Union and Indonesia were successfully launched and deployed from the Shuttle but failed to achieve their proper operational orbits due to upper stage failures. The satellites were spectacularly retrieved in our November mission and brought back to Earth for refurbishment. NASA and the space insurance industry cooperated closely in this first effort. The two satellites are currently being refurbished, and we understand that the space insurance industry is in the process of reaching an agreement on their resale.

Another of the Shuttle's spectacular missions this year was the repair of the SMM during mission 41-C. On April 6, 1984, the Shuttle rendezvoused with and berthed a partially operational spacecraft, the Solar Max (SMM). The Solar Max spacecraft had been launched in 1980 but was disabled by the failure of its fine-pointing system. The Solar Max Repair Mission used extravehicular activity (EVA) techniques to repair and restore to service the malfunctioning spacecraft. This enabled the Solar Max to resume its program of solar observations and measurements in the visible, ultraviolet, and x-ray portions of the spectrum.

The Long Duration Exposure Facility (LDEF) was also deployed on this same mission. This facility supports a large number of long duration exposure experiments. It will be retrieved later this year.

For this mission, we employed for the first time an ascent technique known as direct insertion. This technique, used for high orbital altitude requirements, uses the Shuttle's main engines to achieve the desired apogee - in this case, 250 nm. Because only one Orbital Maneuvering Subsystem (OMS) burn is required to circularize the orbit following main engine cutoff, the OMS propellant is conserved for later use in the missions. This technique eliminates the need for additional OMS tank kits for high altitude payload delivery missions.

On a direct insertion ascent, the external tank enters the atmosphere over the Pacific Ocean rather than the Indian Ocean. Using airborne and ground-based optical and radar instruments, we were able to gain valuable data on the External Tank (ET) entry, break-up, and debris "footprint" following its entry south of Hawaii.

The next mission, STS 41-D, in August 1984, provided a step towards improved electrical power systems for Space Station and future interplanetary spacecraft with the lightweight deployable solar array (OAST-1). This 13 x 102 foot array demonstrated erection from and retraction into a 7-inch deep container. Measurements were made of the dynamic response to induced vehicle motion, which verified and refined analytical techniques.

In addition to the retrieval of the Palapa and Westar satellites mentioned previously, we also had another first involving commercial communications satellites -- we successfully launched and deployed three such satellites on the STS 41-D mission.

On Shuttle flight 41-G, the capability to refuel spacecraft on orbit was demonstrated for the first time completing the initial three "R's" of the National Space Transportation System of Retrieve, Repair, and Refuel. The flight demonstration included six transfers of hydrazine fuel between a resupply tank and a simulated spacecraft propulsion tank utilizing existing flight fill ports. The Orbital Refueling Demonstration tanking system can now be configured for operational use to refuel spacecraft.

Our flights have served many engineering objectives and have provided outstanding scientific benefits as well. The resounding success of the first Spacelab mission on STS-9 is a prime example. The Spacelab program had a banner year in FY 1984. The first Spacelab mission, a system verification and science gathering mission, was an unqualified success. The joint NASA/European Space Agency mission demonstrated the versatility and broad application of Spacelab as a space research facility. The Spacelab-1 mission yielded a significant science return because of the manned operations and their direct involvement with the experimenters on the ground.

The initial operational flight of the Spacelab Pallet System successfully supported the Office of Space and Terrestrial Applications (OSTA-3) mission, wherein a significant amount of new data was collected relative to the Earth's characteristics using a radar instrument. The Spacelab pallets were also used on the satellite retrieval mission and served as the carrier for the two satellites which were returned to Earth. The Multipurpose Experiment Support Structure was used on the OAST-1 mission, an experiment involving deployment of large structures in space and the Large Format Camera.

The first of three satellites to monitor solar radiation received by, and thermal radiation from Earth for effects on weather and climate shift, the Earth Radiation Budget Satellite (ERBS), was also launched. This 5000 lb. spacecraft was lifted out of the bay, the appendages were erected, and it was checked out and deployed at 160 nm. It used its own propulsion to reach its operating orbit of 379 nm at 57 degrees inclination. Full operation has been verified, and results are coming in.

Also notable is the operation of the Shuttle Imaging Radar (SIR-B), which extended the technique used on STS-2 (SIR-A) to higher inclination for greater geographical coverage (57 degrees). The higher resolution imagery of SIR-B supports investigation in geology, cartography, oceanography, archeology, vegetation studies, etc. The study sites include East Africa, Canada, U.S., Australia, New Zealand, Germany, The Netherlands, Japan, Sweden, Peru, China, Saudi Arabia, India, Atlantic and Pacific Oceans, the North Sea, and others.

The Large Format Camera provided high resolution (70 ft), wide field of view (140 x 280 statute miles) with stereoscopic coverage.

Other investigations included wide-scale Measurement of Air Pollution from Satellites, ground Feature Identification and Location Experiment, Auroral Photography Experiment, cloud photography, and direct oceanographic observations done by an onboard Navy oceanographer.

Flight crew members made important contributions to the advancement of the STS during FY 84. During the STS 41-B mission, Mission Specialists (MS) Bruce McCandless and Robert (Bob) Stewart successfully flight tested two Manned Maneuvering Units (MMU's) by propelling them over 300 feet away from Challenger's payload bay and back.

Commander Robert (Bob) Crippen and Pilot Francis (Dick) Scobee demonstrated the Orbiter's navigation and maneuvering capabilities during the Solar Maximum Repair Mission (STS 41-C) by rendezvousing with the SMM satellite. MS Terry Hart exhibited the versatility of the Remote Manipulator System (RMS) by maneuvering the RMS arm to grapple the satellite when the MMU was unable to dock with and stabilize the spacecraft. MS George (Pinky) Nelson and James (Ox) van Hoften repaired the SMM satellite, and the RMS was used to release it back into orbit. The STS 41-C crew successfully demonstrated the capability to repair satellites in orbit.

MS Judith (J.R.) Resnik operated the 102 ft. OAST-1 solar array during the STS 41-D (Rev) mission and obtained valuable data on the performance and structural dynamics of the large, low-cost, lightweight, deployable/retractable structure. In the future, a similar solar array may be used to supplement the Orbiter's power and may be applied to the development of NASA's Space Station.

During the STS 41-G mission, MS David (Dave) Leestma and Kathryn (Kathy) Sullivan performed an EVA to install a flex-line mod kit in an Orbital Refueling System (ORS) prototype. Liquid hydrazine was safely passed through the flex-line, demonstrating the capability of refueling satellites in orbit.

Commander Frederick (Rick) Hauck and Pilot David (Dave) Walker demonstrated the navigation and maneuvering capability of Discovery during the

STS 51-A mission when they rendezvoused with the Palapa and Westar satellites. MS Joseph (Joe) Allen and Dale Gardner utilized MMU's to fly over and capture the two satellites, and then berthed the satellites in the payload bay after participating in real-time planning to modify the original berthing procedures. The STS 51-A mission highlighted the capability of the Space Shuttle program to retrieve satellites.

Payload specialists played a major scientific role in this year's flights. The first industry payload specialist, C.D. Walker from McDonnell Douglas, operated the Continuous Flow Electrophoresis System (CFES) experiment which exploits the microgravity of orbital flight to improve the separation of large organic molecules for production of new pharmaceuticals. An additional flight is planned leading to a pilot production version to operate in the payload bay.

P.D. Scully-Power, an oceanographer from the U. S. Navy, did direct interpretation of oceanographic phenomena as observed from space augmented by hand-held photography and correlated with radar and LFC imagery.

Additionally, Canadian payload specialist Marc Garneau conducted Canadian experiments (CANEX) involving automatic video analysis for ranging and tracking, composite materials exposure, sun photometry, atmospheric emission and Shuttle glow, and space adaptation studies.

Another of our exciting programs is the Space Flight Participant Program which we established this spring as a means to include private citizens on Shuttle missions. On August 27, 1984, President Reagan announced that the first space flight participant would be selected from among the Nation's elementary and secondary school teachers.

The Announcement of Opportunity outlining the eligibility requirements for teacher candidates was released on November 8, 1984, generating requests for information from 35,000 teachers in the United States, our territories, and dependent overseas schools.

The Council of Chief State School Officers has been contacted by NASA to conduct the search. A primary and back-up candidate will be announced in September of 1985. An early 1986 mission will be identified on which the teacher will fly.

Program Status and Plans

During FY 84, we have continued to take steps to make the Shuttle fully operational and cost effective.

The fourth Shuttle Orbiter, Atlantis, will join the fleet this spring and is scheduled to fly its first mission this year. Although we are well into the Shuttle's operational phase, we will continue to work to improve performance, procure spare parts, and enhance reliability.

In the production phase, the effort of delivering orbiters will have been completed in FY 1985 with the delivery of Atlantis. The modifications to Columbia, bringing it to its operational configuration, will have also been completed.

There are continuing activities in the production phase -- the completion of modifications to Atlantis and Discovery to accommodate the Centaur upper stage, performance augmentation activities to conduct orbiter loads analysis in support of the Solid Rocket Motor Filament Wound Case Development Program, and the design of flight software.

A new production activity is the upgrading of the General Purpose Computer (GPC). The new GPC provides needed ascent memory and ties us with the industry trend to standard architecture while preserving our current software investment.

The logistics activities include both structural spares and initial spares. The structural components include elements such as wings, vertical stabilizer, crew module, payload bay doors, and aft thrust structure. These elements will be assembled into varying stages of completion to be used as structural spares for the current fleet.

Logistics support includes the lay-in of Orbiter initial spares and rate spares to meet the requirements for a twenty-four per year flight rate. Maintenance test equipment is also provided as part of the interim depot and maintenance support. Final determinations on depot and maintenance support are under study.

A team consisting of USAF military and contractor personnel, supplemented by experienced Kennedy Space Center personnel, has been established at VAFB. Through their cooperative efforts, good progress continues to be made in preparing the launch site for the first launch, now scheduled for no earlier than January 29, 1986. All construction activities are proceeding with no known schedule impacts.

The facility verification vehicle (OV-101/Enterprise) was delivered last November, followed by the ET and inert Solid Rocket Booster (SRB) segments, and facility verification testing is under way. Delivery of the first flight vehicle (OV-103/Discovery) is scheduled for September 1985.

Since last year, there has been a major replanning of the Space Shuttle Main Engine (SSME) program. The restructured program consists of three parts -- (1) flight operations, (2) product improvement, and (3) advanced development. The flight operations continues virtually unchanged from last year. The near-term portion of the product improvement element also continues virtually unchanged from last year. The emphasis of the near-term product improvement is on improved high pressure pumps, a redesigned powerhead, and a more efficient production process. The out-year portion of the product improvement element, being conducted at the prime SSME contractor, was significantly reduced and the advanced development element created.

The advanced development element has two major thrusts -- alternative engine contractors and a technology test bed. Two rocket engine companies, Aerojet and Pratt & Whitney, are studying the SSME with a goal of improving the SSME life by applying alternative approaches and/or advanced technology to problem areas. In subsequent phases of this competitive effort, the alternative contractor(s) will fabricate and test hardware. The details of the technology test bed program are still evolving but will be accomplished at Marshall Space Flight Center (MSFC). One use of the technology test bed will be to test the hardware that is produced from the competitive effort.

The final FWC qualification test firing is scheduled for the fourth quarter of FY 1985. The first FWC SRM flight set will be loaded and assembled for delivery to VAFB in the third quarter of FY 1985 in support of the first flight.

Efforts will continue toward minimizing hardware damage at water impact and incorporating producibility improvements to reduce hardware turnaround time.

Twenty-four boosters (12 flight sets) will be delivered to KSC in FY 1985 to support the flight mission model.

In the ET, procurement of additional tooling will continue the buildup of our capability to support higher flight rates. Producibility and production readiness efforts will complete implementation to further enhance manufacturing process to achieve planned cost reductions. Eleven tanks are scheduled for delivery in FY 1985.

Transition of Ground Support Equipment (GSE) from the NASA Flight Element Projects to KSC is nearly complete for all but the Orbiter project. This consolidation provides for a more efficient logistics initial lay-in and sparing system at our primary launch and landing site. The Orbiter GSE transfer will be completed in 1985. Consolidation of flight hardware at KSC has been initiated and will further increase logistics sparing effectiveness in the coming years.

During the past several years, there has been concern over the logistics spare quantities available to support the Shuttle flight operations. Of special concern has been the high pressure pumps for the Space Shuttle Main Engines (SSME's) following our concentrated effort to reach our complete spare goals. I am happy to report that we have seen progress this past year. At the end of FY 84, our two operational Shuttles were completely equipped with SSME's including a full complement of high pressure pumps. In addition, there is a spare engine, including pumps, at KSC. The main propulsion system testing at full power level (109% thrust) has been on hold until sufficient high pressure pumps became available. Testing is now planned for the April/May 1985 timeframe.

To accommodate our expanding fleet and operational capabilities, the Solid Rocket Motor (SRM) Processing Facility is under construction at KSC to enable safer and more efficient processing and storage of the SRM's and aft segments.

We are now constructing a new Solid Rocket Booster (SRB) Refurbishment Facility in order to move the Marshall Space Flight Ccenter/BAC (Booster Assembly Contractor) activity from the KSC Vehicle Assembly Building (VAB) low bay to enhance safety and increase the capacity from 16 to 24 or more flight sets per year.

Other major activities will include the continuing activation of launch pad B, leading to its planned operational readiness in January 1986; activation of the third mobile launch platform, leading to operational readiness in September 1986; and launch equipment modifications to provide the capability to service the Centaur upper stage for initial Centaur flights. This is a tight, but doable, schedule to support the Galileo and Ulysses missions. Modifications to improve the capability of the Spacecraft Assembly and Encapsulation Facility (SAEF-2) have been completed. We also brought into use a second payload canister which enhances payload operations. Construction and activation by January 1986 of a cargo servicing facility is currently under way.

The modification of a third Gulfstream II for use as a Shuttle Training Aircraft (STA) will be completed, and the STA will be delivered in FY 1985. We are also evaluating the potential for obtaining a second Shuttle carrier aircraft.

This year saw the first full year of operations at KSC under the Shuttle Processing Contract (SPC) and the Base Operations Contract (BOC). Both contracts continue to show increased efficiencies. Lockheed Corporation, the SPC, was fully responsible for the successful turnaround processing of STS 41C and the three subsequent missions. Under the SPC, turnaround capability has continued to improve.

At the Johnson Space Center (JSC) we are planning a Space Transportation System Operation Contract (STSOC) to consolidate work now being performed by 16 contractors into a single contract. The selected contractor will assume increasing responsibility to perform and manage STS operations functions. The Government, however, will retain final authority for mission readiness, mission conduct, and mission safety.

The STSOC contractor will be expected to maintain high standards of safety and reliability for STS missions, introduce new and innovative management procedures to improve efficiency and productivity, reduce the total cost of STS operations, and accommodate a flight rate which is projected to increase to 24 per year.

The Request for Proposal (RFP) for the STSOC contract was released on January 14, 1985. This procurement represents significant changes in contract philosophy for the STS operations era. These changes should produce further reductions in STS operations costs while maintaining space flight quality products and services on a timely basis. This would be accomplished by: (1) consolidating like functions; (2) reducing and streamlining the multiplicity of management and technical interfaces among the different contractors and their NASA counterparts; (3) turning over more of the overall integrated management and end product responsibility to the contractor; and (4) providing the contractor with significant motivation for cost savings through the availability of an incentive fee for cost performance in combination with, and balanced by, the more traditional award fee for technical performance. An additional benefit of these changes will be the opportunity it provides NASA to selectively withdraw its personnel over time and reassign them to other priority programs.

As you are well aware, because of our commitment to achieve 24 flights per year, with 20 at KSC, we are placing strong emphasis on our ability to turn around flight hardware in an expeditious manner. Our initial experience between STS-1 and STS-2 was a turnaround of 187 working days. Continuous planning and optimization of activities, hardware, support equipment, and facilities have resulted in reducing this turnaround time on the same vehicle to 53 working days. This is projected to continue to improve in order to achieve a 35-workday turnaround in 1985.

We have begun implementing a plan to optimize major hardware production and provide flexibility in hardware production rates. A production base flight rate has been established that includes the firm flights plus minimum reflight capability. This flight rate is used for basic contract content for major flight hardware. In addition, a surge flight rate that includes the next level probability flights has been identified. Prepriced contract options for hardware will be used to support surge flight rates. Production base plus surge flight rates are the basis for budget content. Because of long manufacturing lead times, surge flight levels will be reviewed on an annual basis, so surge options will be implemented as soon as firm needs are verified.

The SSME had another year of excellent flight performance, although there was the launch abort of mission 41-D, which resulted from a malfunctioning main fuel valve actuator. Four Shuttle flights were completed with no SSME anomalies which affected flight performance. Certification of the SSME at the 104% thrust level continued and is scheduled for completion early in CY 1985. When completed, the certification program will have demonstrated an equivalent of 40 flights on each of two samples and, by definition, the SSME will then be certified for 20 flights at 104% thrust. The SSME ground test experience now exceeds 1,170 tests totaling approximately 226,000 seconds. Included in these ground tests are 420 tests exceeding 50,000 seconds at the full power level (109%) thrust. Also, during the past year, 46 major components and 3 complete engines were manufactured.

As I noted last summer, we have experienced life design deficiencies at the 109% thrust level, and these deficiencies are primarily in the high pressure turbopump lifetimes. The agency has had in place for sometime a multiphase development program to alleviate these life deficiencies, and that development program has been very successful. During the second quarter of FY 85, we will begin formal certification of improved high pressure pumps, which we expect to demonstrate significant improved life. In addition to direct pump improvements, we also have under way the development of a two-duct hot gas manifold which will improve the operating environment of the pumps. The two-duct manifold represents a modification of one portion of the existing powerhead and, while it will not increase the life of the high pressure pumps, it is expected to give increased operating margin and, consequently, improve safety/reliability of the pumps. The design of the new hot gas manifold is complete, and fabrication of new manifolds has begun. Development testing will begin in FY 1986.

We have had a problem in the past with a shortage of SSME flight hardware. This shortage is primarily with the high pressure pumps. The efforts to improve pump life, noted above, will partially alleviate the shortage, but the agency and the prime SSME contractor, Rocketdyne, have under way an effort to make more efficient the entire engine manufacturing process with emphasis on the high pressure pumps. Included are new and overhauled machine tools, many more digitally-controlled machine tools, a dedicated pump manufacturing area, a dedicated pump overhaul center, additional suppliers of critical piece parts, and an automated system for handling the inspection/anomaly resolution paperwork.

During FY 1984, twelve SRB's, which amounted to six flight sets, were delivered to KSC. In addition, inert SRM and SRB structural components were delivered to the Vandenberg Launch Site (VLS) for assembly of the facility verification vehicle which will be used to verify the vehicle and facility interfaces. The expansion of the existing refurbishment and assembly facilities at KSC to provide the capability of assembling 16 flight sets per year was essentially completed with only minor modifications still to be worked. The incumbent contractor, United Space Boosters, Inc., (USBI) won the recompetition for the assembly and refurbishment of SRB's, and development of larger main parachutes to minimize hardware damage at water impact was completed.

The development of the Filament Wound Case (FWC) for the SRM's achieved several major program milestones during the past year. The full segment development hydrotests were successfully concluded, and design verification data on the composite and composite to metal joint strength were obtained through demonstrating the required margin of safety. Following a Preliminary Design Review, the design and premanufacturing process were fixed, and the processing of the segments for the first flight set was initiated. By the end of the fiscal year, all segments for the first flight from Vandenberg Air Force Base (VAFB) were wound, and all segments for the first static test (DM-6) were manufactured, loaded, and assembled in the test stand for testing at the end of October 1984. In addition, all four case segments for the second static test (DM-7) were manufactured and delivered to Morton-Thiokol for propellant loading. The Structural Test Articles were also delivered to MSFC for testing of dynamic loading under pressure. Significant weight savings were achieved, and increased payload capability resulting from the FWC is now estimated at 4600 lbs. Significant accomplishments were made in recovering from technical problems and schedule difficulties to permit NASA to deliver the first flight set to VAFB in support of the first flight. The assembly of the first FWC development motor was completed in the static test facility, with the firing in early FY 1985.

In addition to the continuation of the FWC development program, the first of three planned parachute drop tests of the FWC drogue parachute was successfully completed, and activity continued to protect the thrust vector control system to reduce hardware damage.

The External Tank (ET) Program has had another exceptionally productive year in 1984. Continued emphasis on cost reduction has resulted in significant savings commitments by the contractor. Plasma arc welding was implemented on two additional tools. The delivery of ten flight units during 1984 included the first unit to be delivered to VAFB. An incentive contract was signed with Martin Marietta Aerospace for the production of tanks through ET-60, and an RFP was released for the production of tanks through ET-120.

The Payload Assist Module (PAM) Program had nine PAM-D flights during FY 1984, and continued development of the PAM-DII. Both of these are commercial programs by McDonnell Douglas Corporation. There were two mission failures -- Westar-VI and Palapa B-2, both on STS-11 in February 1984. Since the failure of the two PAM-D upper stages on the February STS flight, seven PAM-D's have been flown successfully. The resumption of PAM-D flights was permitted only after an extensive failure review process was completed and the probable cause pinpointed and corrected. In addition, seven PAM flights are planned for FY 1985. During FY 1984, NASA led a DOD/NASA/Industry examination of the U.S. state-of-the-art for design, building, testing, and using SRM's containing composite materials. As a result of this examination, and to further enhance confidence, NASA has initiated a SRM Integrity Program to assist industry in further understanding the critical materials and processes used in the manufacture of SRM's.

The STS/Centaur development for both the common Centaur G and the NASA planetary Centaur G Prime vehicles is continuing. The design phase for both configurations has essentially been completed by the successful Preliminary and Critical Design Reviews. The G Prime test vehicle has been fabricated and is presently in structural dynamic tests. G Prime component qualification tests are also proceeding at this time. Fabrication of the flight vehicles for the Galileo and Ulysses missions is under way and is proceeding on or near schedule. The RL-10 engines for these missions have been built, tested, and sent to Convair for installation on the flight vehicles.

During 1984, the Transfer Orbit Stage (TOS), being developed commercially by Orbital Sciences Corporation (OSC) and Martin Marietta Corporation, successfully completed its Preliminary Design Review, Phase I Safety Reviews, and Software Critical Design Review under contract with OSC. NASA technical oversight is being provided by a TOS Project Office at MSFC.

In FY 1985, the TOS development will continue with the Critical Design Review planned in March. The Phase II safety reviews will also be completed.

The Inertial Upper Stage (IUS) launched a DOD mission from the Shuttle in January and Tracking and Data Relay Satellite (TDRS-B) in February 1985. The earlier failure of the IUS in April 1983 was identified as the collapse of the second stage nozzle Techroll Seal (TRS), a flexible ring which allows the nozzle to move and provide directional control. Design changes have been identified and incorporated into the remaining flight vehicles, and full-scale motor verification tests have been conducted by the NASA/DOD industry team.

In 1984, the Orbital Manuevering Vehicle (OMV) preliminary design studies were initiated through a competitive award process with systems studies being conducted by TRW, Martin Marietta Aerospace, and LTV. Orbital Transfer Vehicle (OTV) preliminary concept studies were also awarded in which major systems issues will be addressed particulary relating to utilization at the Space Station. Advanced tether systems applications underwent the first round of engineering analysis in preparation for more detailed studies of the selected candidates. Plans for the Shuttle Derived Launch Vehicle (SDLV) are subject to the results of discussions with the Department of Defense which are now under way.

The hardware development phase of the Tethered Satellite System (TSS) Program was initiated in 1984. This satellite system is a joint U.S./Italian development which will provide a new capability for conducting space experiments in regions remote from the Space Shuttle Orbiter. The objectives of the initial mission are twofold -- to verify the controlled deployment, operation, and retrieval of the TSS and to quantify the interaction between the satellite and tether.

The design and development of the TSS will be continued through Preliminary and Critical Design review stages in 1985 leading to the delivery of a flight article in early 1987. Plans for the first flight are late 1987 or early 1988.

NASA's Expendable Launch Vehicle (ELV) Program reached a milestone in 1984 with the launch of its 401st vehicle since inception of the program in 1960. The most active NASA vehicle, the Delta, was used in four launches during CY 1984 and established a new record of 43 launch successes in a row. In addition, launches of one Scout, one Atlas, and one Atlas Centaur were conducted in 1984. All were successful except the Atlas Centaur launch attempt of one Intelsat communications satellite in June 1984. The vehicle failed to place the spacecraft into its proper transfer orbit. An investigation has been conducted, and testing of recommended corrective measures are under way prior to resumption of launching in early 1985.

Although no NASA funds are being requested to support ELV's in 1985, 12 missions are planned to be launched for other U.S. Government and nongovernment users on a fully reimbursable basis. These vehicles are being used to fulfill NASA commitments made during the transition of Shuttle development and operations.

NASA is proceeding to implement national policy to commercialize ELV's as outlined in President Reagan's Policy NSDD-94 dated May 16, 1983. Three of NASA's ELV's are being considered for commercial operations at this time -- the Delta, the Atlas Centaur, and the Scout. Since we talked to you last year, NASA has solicited proposals for commercial operation of the Scout. This overall effort is proceeding slowly. None of the commercial operators have been successful in marketing any mission users to provide an initial impetus to this new enterprise.

The fabrication of the last major component in the European Spacelab Program, the Instrument Pointing System (IPS), was completed and delivered to KSC at the beginning of FY 1985, while qualification testing continued in Europe. It is in the process of being checked out and integrated with the other Spacelab systems, and the experiments for its maiden voyage and verification on the Spacelab-2 mission to be flown later this year. In the U.S., while the initial Spacelab missions are being carried out, we are continuing to build up our operational capability with the establishment of our logistics systems and inlay of spares, and the completion of the expansion of the Software Development Facility to support the planned flight rate.

In FY 1985, the Hitchhiker development program was begun, and, when completed later this year, will add two small payload carriers to the Spacelab stable which will permit rapid access to space at a reduced cost for many new experimenters. The outfitting of one of the Spacelab pallets for specialized structures technology experiments was also begun this year. In order to handle the planned flight rate, the design and fabrication of a second Payload Operations Control Center (POCC), located at MSFC, was initiated and is planned to be completed in time to support the ASTRO-1 mission in FY 1986.

Prior to the Spacelab-2 mission, the first operational Spacelab mission, Spacelab-3, will be flown using the same basic manned module configuration as Spacelab-1 to carry a series of new experiments into low-Earth orbit. The Environmental Observation Mission-1 (EOM-1), which will carry some of the Spacelab-1 experiments back into orbit, will now be combined with the Environmental Observation Mission-2 (EOM-2) for increased efficiency. This mission will be flown in FY 1986.

Preparations will continue in FY 1985 to conduct specific Space Station-related experiments, including the EVA assembly of structures in early FY 1986, a series on the dynamics of large structures starting in FY 1988, and a series using Hitchhiker to provide basic design data, such as capillary pump performance and plasma solar array interaction, also starting in early FY 1986. In addition, all Spacelab flights will be an invaluable preparation and experience for Space Station.

In Advanced Programs, the OMV preliminary systems design will be accomplished, the OTV preliminary concepts will have been completed, the detailed systems engineering of advanced tether applications will have been fully initiated, and the preliminary design will have been initiated during FY 1985. The base program will continue to conduct studies and advanced developments in satellite services, crew systems, advanced transportation systems, spacecraft systems related to advanced tether applications and geostationary platforms, and land generic space systems capabilities such as artificial intelligence applications to operational problems.

In January 1985, we successfully conducted the first dedicated mission for the Department of Defense.

Current planning for STS reimbursable launches for 1985 includes the launching of 15 communications satellites and two missions for the DOD. The communications satellite customers include Mexico, ARABSAT, USSAT PTY. Ltd., Western Union, AT&T, American Satellite Company, RCA American Communications, Telesat Canada, Hughes Communications Services, Inc., SPACECOM, and others.

In addition, we have received new requests for reservations on the STS in 1987 and beyond from the People's Republic of China, the Government of Italy, and SPACECOM for communications satellites and from the Federal Republic of Germany for a follow-on Spacelab mission.

FY 1986 BUDGET REQUEST

The total budget authority requested for the STS Program for FY 1986 is $3160.9 million. Within this request, an amount of $2701.6 million is requested in the appropriation titled Space Flight, Control, and Data Communications. Activities covered here include Shuttle Production and Operational Capability and Shuttle Operations. $459.3 million is requested in the Research and Development appropriation for Space Transportation Capability Development which provides for Upper Stages, Engineering and Technical Base, Spacelab, Payload Operations and Support Equipment, Advanced Programs, and Tethered Satellite System.

Shuttle Production and Operational Capability

The objectives of this program are to provide for the completion of the national fleet of Shuttle Orbiters; the production and capability development of the propulsion systems; the mission preparation, mission control, and launch site capabilities; and the potential changes and upgrading of the STS. To support these objectives, we are requesting $976.5 million in FY 1986. This represents a $516 million reduction from the current FY 1985 estimate.

Orbiter

To continue successful Orbiter production activities in FY 1986, we are requesting $[illegible].6 million. This funding supports both production and logistics activities.

With the flight rate going up and the Orbiter Production Program winding down, there is continued emphasis on the Orbiter Spares Program. The initial increment of structural spares has been defined and negotiated with deliveries scheduled through 1987. This program provides a set of major structural components to be used in the event of damage to an Orbiter, while helping to maintain a production base, and potentially reducing the lead time to build an additional Orbiter, if one should be required in the future.

The procurement of spares and repair capability to support the planned increased flight rate is continuing on schedule. The initial lay-in of spares, which will support up to 12 flights per year, will be completed in 1986. Flight rate spares, test equipment, and repair capability to achieve 24 flights per year are an ongoing activity.

Launch and Mission Support

The budget request calls for $163.9 million for launch and mission support. Major efforts at KSC include activation and readiness of launch Pad B, activation of the third mobile launch platform, and equipment modifications to provide the capability to service the Centaur upper stage for the initial Centaur flights.

Full flight rate capability will be achieved for each component of the ground data systems (flight design, mission control, and simulators). We will use the results of the FY 1985 studies to make a decision on an in-flight refueling capability for the Shuttle Carrier Aircraft (Boeing 747) in FY 1986, satisfying a system requirement. The replacement of equipment dating from the Apollo and Shuttle Design, Development, Test and Evaluation (DDT&E) periods will become a major effort as will the project to extend the operational life of the T-38 training and pilot proficiency aircraft.

Propulsion Systems

In FY 1986, $454.0 million is requested for propulsion systems. Funding for the main engine provides for those activities necessary to support the Orbiter production, flight schedules, and ground testing. Other ongoing activities will include flight spares lay-in, anomaly resolution testing, and continued certification and development testing.

In the SRB Program, we will continue hardware producibility improvements to reduce turnaround time on reusable hardware and continue efforts to reduce hardware damage during water impact. Construction of the new Refurbishment and Assembly Facility at KSC will be completed. The fabrication of FWC segments will continue, and the development testing will be completed. During FY 86, twenty six boosters (13 flight sets) will be delivered to support KSC and VAFB flights.

Production rate of ET's will continue to increase on plan with 12 tanks scheduled for delivery in FY 1986.

Changes and Systems Upgrading

Management, technical flight experiences, and cost reviews of the Space Shuttle program have stressed the need for providing an adequate allowance for changes and modifications which are required in a large, complex, and technically demanding space system. We are requesting funding of $25.0 million in this area to provide the capability to undertake those changes and upgrading of flight and ground systems needed in the Space Shuttle program. Improvements to system safety, reliability, performance, and cost effectiveness are the key objectives.

Shuttle Operations

Shuttle operations direct appropriated funds are combined with reimbursements received from other U.S. government, commercial, and international customers to support the procurement of flight hardware for launch and flight operation requirements. For FY 1986, $1725.1 million is requested in direct appropriations. The Shuttle operations budget request includes funds in three principal areas -- flight operations, flight hardware, and launch and landing operations. This anticipates the receipt of about $400 million in Shuttle reimbursements.

Flight Operations

The flight operations request of $425.2 million provides for the maintenance and operation of the onboard avionics software, mission control systems, as well as astronaut training and flight proficiency aircraft and simulators. It also includes sustaining engineering required to integrate all flight elements (including contractor support at the launch sites) and to assure systems safety. The amount required over the core of the Shuttle Avionics Integration Laboratory (SAIL) is provided to test and verify operations software and hardware modifications. Flight operations also include Getaway Special support managed by the Goddard Space Flight Center and the payload integration activities at Johnson Space Center. At JSC, support is included for flight crew mission requirements and safety certification, operations and maintenance support, printing, equipment rentals, and materials for base operations activities.

Flight Hardware

$964.0 million is being requested for flight hardware in FY 1986. Orbiter flight spares and crew equipment spares are based on calculations involving flight rates, maintenance schedules, operational hours, turnaround times, and procurement lead times for spares. The structural spares program, which was initiated in FY 1983, is continuing with deliveries of all major modules scheduled by FY 1987. Main engine hardware provides for manufacturing and delivery of overhauled engines and engine component spares.

Launch and Landing Operations

Launch and landing operations funding of $335.9 million in FY 1986 provides for manpower to process and integrate elements (SRB, ET, Orbiter, payloads) prior to launch, to retrieve the SRB's for refurbishment, and for orbiter landing and return for future flights. Funding also supports sustaining engineering, logistics, launch processing systems, and facility and equipment maintenance. Also included are the projected savings resulting from the consolidated base operations and the SPC's at KSC.

In FY 1986, we plan to achieve the launch of Galileo and Ulysses in the same launch window (six days apart.)

Expendable Launch Vehicles

Eight expendable launches are planned in 1986 in continued support of other U.S. Government and nongovernment users. The vehicle systems being used have completed production and are in inventory to fill user demands. This program is being phased out with the potential for operation by commercialized entrepreneurs.

RESEARCH AND DEVELOPMENT

Upper Stages

In FY 1986, $122.0 million is requested for upper stage development, procurement, and operational requirements.

These funds will provide for accomplishing the first two Centaur/STS missions -- Galileo and Ulysses in May 1986. In addition, continued procurement and operational support of the IUS for TDRS-D, Centaur/STS vehicle for the Venus Radar Mapper (VRM), TDRS-E and F, one PAM-A vehicle for the Advanced Communications Technology Satellite (ACTS), Upper Stage Program monitoring for PAM and TOS, and efforts related to an SRM Integrity Program, are included in the fund request. Although we have baselined our budget planning on the Centaur/STS vehicle for TDRS-E and F, and on the TOS for MGCO, we plan to hold a competition among the upper stages capable of performing these missions.

Engineering and Technical Base

In FY 1986, a funding level of $105.7 million is requested to support the core engineering base necessary to sustain a continuing capability in space transportation and manned flight. The engineering and technical base (ETB) budget line was established in FY 1983, in response to the Subcommittee on Space Science and Applications action to "assure adequate support of the research and development institutions" specifically addressing "the period during which Shuttle operations are beginning and Shuttle development is completed ....." As you may recall, while the Civil Service staffing configuration of the NASA Centers differ from Center to Center, more than three-fourths of the staff are professionals. Most of the necessary technical support for our working Civil Service professionals is provided through support contractors and other procurements funded by the ETB budget.

The ETB budget provides the support necessary to operate a core of Research and Development (R&D) facilities and laboratories for a five-day, one-shift operation at designated OSF Centers. The expert contractor technicians and operators provided in this budget line item, plus other support, such as consumables and equipment, assure the effective operation of a core capability within the OSF Centers. The Civil Service professionals rely on the technical facilities and operations, in order to conduct R&D tests and analysis.

Spacelab

The Spacelab FY 1986 budget request of $96.7 million dollars will complete most of the development program in the U.S. and primarily be used to integrate and operate the Spacelab system. The procurement of additional flight hardware to support the planned flight rate and the Dedicated Discipline Laboratory (DDL) missions will continue in FY 1986. The DDL's will save costs by permitting certain payloads to be reflown without deintegration and reintegration between missions. The FY 1986 funding will be used to complete the Spacelab Pallet System which will permit the mixed cargo use of the Igloo Pallet configuration for the viewing of the Halley's comet with the ASTRO-1 mission in that year.

Spacelab operations in FY 1986 will require funding for the operation of both the POCC's, the ground operations for integration and deintegration of missions, the analytical and software integration, the sustaining engineering, and the operation of the training facilities. The missions which are currently planned to be flown in FY 1986 include the first Spacelab Life Sciences Mission, which will use the manned module, the first dedicated reimbursable mission for West Germany, the combined EOM-1/EOM-2, and a series of smaller payloads such as those carried on the Multipurpose Experiment Support Structures. Also planned in FY 1986 are the first Hitchhiker missions in both the Hitchhiker-Goddard and Hitchhiker-Marshall configurations.

Payload Operations and Support Equipment

The payload operations support equipment program request of $63.9 million provides for payload services which are required beyond the basic standard Shuttle services. Payload operations provides unique hardware, analysis, and STS launch site services. Payload operations funding in FY 1986 is required to furnish continued payload services for currently scheduled NASA launches. Payloads to receive support include Galileo, VRM, Ulysses, TDRS, Space Telescope, and Spacelabs 2 and 3. The funding will also support the investment to complete the POCC located at JSC to support Spacelab missions and provide additional Multi-Mission Payload Support Equipment (MMPSE). The equipment is required to integrate, check out, transport, and provide Orbiter interface to an increasing number and variety of payloads and to provide operational economics through standardization and flexibility.

Advanced Programs

Our requested advanced programs budget for FY 1986 is $21.0 million. Our major emphasis will continue to be placed on satellite services, advanced transportation systems, advanced tether systems applications, geostationary platforms, crew systems, and generic new space systems capabilities.

The advanced work on Shuttle Derived Launch Vehicles (SDLV's) and related advanced developments will continue to be pursued. The Aeroassist Flight Experiment will be initiated in a joint agency program with the Office of Aeronautics and Space Technology to explore aerobraking technologies and techniques for potential future system use on reusable OTV's.

We will continue to conduct a few inexpensive, but critical, flight experiments to demonstrate new national STS capabilities aimed at developing customer confidence in connection with satellite services and orbital operations, such as the Experimental Assembly of Structures in Extravehicular Activity (EASE) and the Assembly Concept for Construction of Erectable Space Structures (ACCESS). We will also be demonstrating a voice-controlled system for the Shuttle closed circuit television which will enhance astronaut productivity and simplify payload operations.

Orbital Maneuvering Vehicle

Our requested funding for the OMV for FY 1986 is $25.0 million. The OMV, which is a reusable, remotely-piloted system, represents a significant extension of capability for the STS, as well as very valuable space infrastructure element for the Space Station. With this FY 1986 initiation, the OMV will be available for flight use in 1990.

Tethered Satellite System

The $21.0 million requested for FY 1986 will be used for continued design and development and fabrication of the flight deployment system planned for flight in 1988.

THE FUTURE

We are understandably proud of the Nation's Space Transportation System and the STS team's many mission accomplishments and our demonstrated capability to repair, retrieve, and refuel spacecraft. The success of man and machine capability in these missions once again demonstrates the soundness of the President's Space Station program.

The STS team will continue to vigorously pursue improvement in the efficiency, reliability, and flexibility of the STS and ensure that our organization provides the best possible customer support. With your help, the management challenges that lie ahead in bringing the system to full operational and cost-effective use will be met.

We are determined to continue to help this Nation provide leadership in space transportation. To provide routine access to space at the lowest cost, we are working aggressively to meet the projected flight rate in a cost-effective manner with less total manpower and less total annual expenditures.

The space program has made many significant contributions to the Nation's technological capabilities. The future possibilities for manned operations in geostationary regimes, advanced lunar base operations and exploration, and explorations within our solar system represent new and exciting opportunities -- not only for the United States but also for our international partners. Our dedicated team looks forward to the future and the challenges of fully utilizing the versatile capabilities of the STS including the critical interface with the multinational Space Station.

With your help, we look forward to a challenging and rewarding future.

The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Fifth Orbiter

Question 1: Do your current projections that a four Orbiter fleet will adequately meet future Shuttle launch demands include a dedicated Orbiter at Vandenberg Air Force Base, and, if so, which vehicle will that be?

Answer 1: There is not a "DOD-dedicated" Orbiter. Our manifesting utilizes four Orbiters to meet the NASA/DOD needs. We do recognize, however, that DOD has priority over all other requirements and in the event a scheduling conflict arises, the needs of DOD will be met first.

Question 2: If a DOD-dedicated Orbiter were taken out of commission for a significant period of time, would one of the three non-DOD Orbiters assume the role of the DOD-dedicated Orbiter at Vandenberg?

Answer 2: There is not a "DOD-dedicated" Orbiter. Our manifesting utilizes 4 Orbiters to meet the NASA/DOD needs. We do recognize, however, that DOD has priority over all other requirements and in the event a scheduling conflict arises, the needs of DOD will be met first. Our current projections are adquately met recognizing this position.

Question 3: What are the variables in the Shuttle manifest that could create the need for a fifth orbiter, and why, in your projections, have you not factored in the likelihood of these variables increasing Shuttle demand?

Answer 3: The variables to the need for additional Orbiters include launch rate demand, ground turnaround time and on-orbit time. The Agency is monitoring these requirements and is maintaining production capability to meet launch rate demand when it materializes. At this time, the four Orbiter fleet is projected to meet the requirements through the foreseeable future.

Question 4: If one of the Orbiters in a four-Orbiter fleet was decommissioned for a significant period of time, how would you accommodate a manifest of 24 launches in a year?

Answer 4: If one of the Orbiters in the four-Orbiter fleet was decommissioned for a significant period of time, the Agency could accommodate a manifest of 24 launches per year for a limited period of time by surging from 5 days per week/3 shifts per day (holidays off) to 7 days per week/3 shifts per day (working all holidays) at KSC.

Question 5: NASA is in the middle of a multi-year $460 million program to augment its Orbiter structural spares inventory. How and to what extent could these structural spares be used to build a fifth Orbiter?

Answer 5: Should the decision be made to build a fifth Orbiter, all of the structural spares could be used in the fabrication and assembly of the vehicle. Substantial effort would still be required on these elements as they are completed only through the primary structures phase but these structural spares would reduce the time necessary to build a fifth Oribter.

Question 6: What impact would such an approach have on the Orbiter structural spares inventory?

Answer 6: Should the structural spares inventory be used as the for a fifth orbiter, the structural spares we have on order at this time would be used. A decision would be made at that time as to the need for any replacements of the spares inventory.

Question 8: At what point do you think the Shuttle System will be mature enough to permit a commercial purchase of an orbiter?

Answer 8: We feel that once the Shuttle system has reached the point where it is fully operational in providing routine access to space, it will be mature enough for commercial purchase. This will ensure that critical performance capabilities have been verified by flight demonstration, major changes will have been recognized and incorporated, our logistics support is in place, the ground and flight processing capabilities are adequate to support 24 flights per year, and that the operational management capabilities are in place.

Question 9: Similarly when will the Shuttle System be mature enough to permit its commercial operation?

Answer 9: The Shuttle system is planned to be operational at the point it is ready and available for routine use in its intended environment. In order to be considered operational, it must also be capable of supporting 24 flights per year. In our current planning the timing for this would be in the 1989 or 1990 timeframe. At that time it is perhaps feasible that the system would be mature enough to permit commercial operations. But, maturity alone would not allow commercial operations, as there are many other considerations, such as, the ability to support DOD security missions, that could complicate such a transition.

Question 10: Concerning NASA's decision not to purchase a fifth Orbiter, how much consideration was given to the possible development of a second generation Shuttle and an unmanned Shuttle-derived Launch Vehicle?

Answer 10: NASA has not abandonded the fifth Orbiter but is not proposing a start in this year's budget request. We are initiating investigations of a second generation Shuttle which, together with an unmanned cargo vehicle, would suit the needs of a potentially burgeoning space activity in the early 2000s. These newer vehicles might effect the need for a fifth Orbiter in the early 1990s.

Question 11: How long would it take to develop both of these vehicles and when do you foresee the need for both of these capabilities?

Answer 11: The full development spans for these vehicles are estimated to be:

- Shuttle II - 10 years, or slightly longer if existing liquid rocket engines cannot be adapted.
- Cargo Vehicle - 5 to 10 years, depending on extent to which Shuttle technology is appropriate. A new large rocket engine, if needed, would take 10 or more years to first flight.

Anticipated need is post-2000 for Shuttle II and 1995 to 2000 for the cargo vehicle.

Question 12: What is the status of the joint NASA-Air Force study concerning the development of a Shuttle-derived Launch Vehicle?

Answer 12: The congressionally mandated joint NASA/DOD study on Complementary Expendable Launch Vehicles has been completed and forwarded to Congress. NASA and DOD are currently developing Terms of Reference for a joint study which will address technology developments associated with a second generation Space Transportation System, including SDLV configurations.

Question 13: What are likely to be the major differences in capability and design between the present Shuttle configuration and that of a second-generation Shuttle?

Answer 13: The second-generation Shuttle is currently assumed to concentrate on transportation of people and priority cargo for support of the Space Station and other missions. Accordingly, Shuttle II should be capable of delivering substantially more people than the present Shuttle and a variable amount of up/down cargo.

Scientific Opportunities on Space Shuttle

Question 14: According to the recently-released report by the Space Shuttle Science Working Group, modest modifications and enhancements of existing hardware, including both intermediate class carrier systems and Spacelab, can increase flight opportunities and broaden significantly the scope of the scientific research enabled by the Shuttle.

Is NASA considering any such modifications or enhancements and, if so, when will they begin, how much will they cost, and what will they entail?

Would such enhancements or modifications, compromise the present Shuttle configuration or systems in any way?

Answer 14: The Spacelab Program has already developed several systems, or has them well underway, which meet some of the SSWG recommendations for intermediate service to the standard dedicated Spacelab. The so-called Spacelab Pallet System (SPS) provides two versions of a mixed cargo carrier based on European supplied pallets which will fly singularly or in pairs with other deployable cargo and thus share launch costs and increased flight opportunities. These are the Igloo Pallet, which will fly for the first time in March 1986, and the Multiplexer Demultiplexer (MDM) Pallet, which flew for the first time in October 1984. Similarly, the MDM MPESS (Multi-Purpose Experiment Support Structure) provides mixed cargo accommodations for smaller payloads and flew for the first time in June 1983.

The Spacelab Program is also developing another pair of carrier systems called Hitchhiker, which will meet the primary recommendations of the SSWG to provide low cost transportation and rapid response. Both GSFC and MSFC are developing Hitchhiker systems to fit into the forward two sections of the orbiter cargo bay which are unoccupied for most Shuttle missions, the GSFC carrier hanging on the starboard side of the bay and the MSFC carrier spanning the bay. For users with low payload weights, normally less than 400 lbs for MSFC Hitchhiker and 200 lbs for the GSFC Hitchhiker, these systems will allow manifesting as late as six months before flight. To make this possible, the users are restricted to fairly modest power and data management resources and must accept the mission profiles and timelines established by the primary payloads. The initial flights are scheduled for FY 1986. Initial user interest in these new systems has been high.

These systems basically do not compromise the present Shuttle configuration or systems in any way.

With regard to the Shuttle itself, NASA is considering Orbiter enhancements to increase the orbital stay time and to enhance the reliability of the vernier reaction control system.

The orbital stay time of OV-102 (Columbia) has already been increased to approximately 10 days by the addition of a fifth cryogenic tank set of reactants for the electrical power generating system. The STS-9 mission (Spacelab-1) in November/December 1983 utilized this capability. It had been planned to add a similar capability to OV-104 (Atlantis) during its build cycle. Although this was not done, and cannot be done now without impacting the delivery date from Palmdale, we are still committed to configuring a second Orbiter for this longer duration and have budgeted funds for this purpose.

Many of the missions addressed by the Working Group require the use of the Orbiter's vernier Reaction Control System (RCS) for precision pointing, low angular rates, and very low gravity environments. An enhancement to upgrade the reliability of the vernier RCS by providing redundancy is being considered. This effort would require about two years and cost approximately $16 million. It would entail the addition of two redundant vernier thrusters to the forward RCS module including plumbing modifications, displays, controls and electrical wiring. Revisions would also be made to the Orbiter electronics and software for the entire vernier RCS, both forward and aft.

These modifications would not compromise any present Shuttle system.

Shuttle Manifest

Question 15: What competitive factors, both pricing and non-pricing, are you running up against in competition with Ariane for the launch of communications satellites?

How and to what extent have you been able to counter these competitive advantages that Ariane seems to have?

Answer 15: Basic transportation costs: Ariane has flexibility to price launch services to individual market conditions. As a result, they have, on a number of occasions, underpriced the current Shuttle price (based on $71 million in FY 1982 dollars) by $3 million to $5 million.

--Geographical location of launch facility: The proximity to the equator of Kourou, the Ariane launch site, gives them an advantage when the same size Apogee Kick Motor is used to put a spacecraft into geosynchronous orbit. The advantage is manifested in the amount of "station keeping" propellant that can be loaded into the spacecraft at launch or that remains after final orbit placement. The remaining propellant can extend the spacecraft's effective "station keeping" by one to two years when launched by Ariane.

--Ariane also enjoys an inherent competitive advantage because of its inertially-guided third stage. The more precise injection into transfer orbit yields an average of at least a year's added lifetime on orbit, worth millions of dollars in transponder revenue.

--Spacecraft processing time: The Shuttle requires 4 to 5 weeks more spacecraft processing time at the launch site than does Ariane. Every effort is being made to reduce and eventually gain the advantage, but at present it is of some economic value to customers using Ariane.

-- Related business: In addition to the desirability of maximizing profits and benefitting from economics of scale, it is clearly part of European strategy to capture as much of the launch market as possible, in order to gain allied business for European industry. We understand that a central part of Ariane's long-term pricing strategy is to offer package deals with European spacecraft manufacturers in which the combined price is less than those of the launch and satellites separately. In particular, emphasis is being placed on sales of the Spacebus 100, 200 and 300 satellites which are not necessarily dually compatible with the Shuttle. A case in point is the European offer to launch a communications satellite for the Chinese with a price break of $20 million off the combined price of a satellite plus launch package.

This approach would also permit European industry to compete more effectively for ground segment hardware business. It is important to note that satellite and ground segment hardware generally represents at least 75% of the cost of a functioning communications satellite system (launch plus space segment, plus ground segment).

Ariane's present competitive edge will be difficult to overcome. This is especially true as regards pricing. We believe that NASA's 25 years of experience in space launches, the redundancy and reliability of the Shuttle, and the service and repair, as well as the future refueling capability are extremely useful in marketing the Shuttle. However, price is the dominant factor if the other system and their organization is considered to be reliable.

Question 16: According to an article in the February 25 issue of Aviation Week and Space Technology, NASA's Shuttle Customer Services office has started backup planning on how it could shift up to three commercial spacecraft from the Shuttle to Delta ELV's, if the Shuttle is unable to meet its tight schedule into early 1986.

Is NASA capable of launching 10-11 missions in FY 1985 and 13-14 in FY 1986, as presently scheduled; and, is NASA rethinking the policy on ELV's?

Answer 16: We have the capability in place for 10 missions in FY 1985 and 14 missions in FY 1986. Recent problems with the TDRS payload have resulted in a need to reschedule this payload once the anomaly has been fixed. The scheduling of both Galileo and Ulysses during May 1986 ties up both launch pads and limits our flexibility to re-phase flights early in the year, although it does not materially affect our annual flight rate capability. It is a matter of course for NASA to do contingency planning regarding schedule impacts. The occasional implementation of contingency plans, such as, the case of TDRS payload problems and subsequent roll-back of the Orbiter to the VAB on Mission 51E, serves to indicate the effectiveness of NASA's contingency planning. At such a time, it is necessary to adjust the manifest schedule and maximize our capability to meet our customer commitments--including the use of available expendable launch vehicles, if required, to meet our commitments to our customers.

Question 17: In addition to the European Space Agency, other countries such as Japan, China, and the Soviet Union are each expressing varying levels of interest in commercially launched commmunications satellites.

Could you comment on the development of these other launch capabilities and on the likely impact they could have on NASA's projected share of the market?

Answer 17: The launch capabilities of Japan, China and the Soviet Union have and will continue to develop and, in time, could be competitive. We understand that Inmarsat included in its RFP the Soviet Proton as a candidate launch system, and the Soviets have launched an Indian satellite for which they were partially reimbursed. The Chinese have reportedly offered their system on a commercial basis. The Japanese are progressing with their H2 vehicle and may also become a force in the market. To the extent the overall market demand is relatively constant, a flight on a competitor's launch vehicle is a payload lost to Shuttle.

Question 18: Certainly, there is a great deal of interest in the commercial development of space and related activities such as materials processing in space and the development of advanced communications technologies? What impact will commercial activities such as these have on future Shuttle demand?

Answer 18: It is very difficult to put numbers on predictions of space ventures more than about five years into the future. Time has not been kind to long-range predictions made about numbers of flights in the early 1980s. On the other hand, the strength of commitment currently being experienced in the materials processing arena is significant. Characterizations about future space flight must surely account for the potential large flight requirement to satisfy the materials processing endeavors. Developments today are addressing methods to acquire the large power demand concomitant with most materials manufacturing processes and policies are being driven to simplify access to space orbiting factories.

It is anticipated that any growth in the advanced communications or materials processing area will be a well behaved growth exhibiting adequate warning of coming events. If the nature of the growth is as mentioned, the additional resources can be scheduled with confidence of meeting the demand. Orbiters take about 50 months to acquire (assuming the production lines are still in tact), and facilities can be acquired and made operational in about the same time. The planning that will continue in this period will ensure that there is a capability to expand and augment current capacities gracefully, and, at the lowest possible budget risk.

Shuttle Centaur Problem

Question 19: Shuttle/Centaur Problem-- Concerning the recently revealed problem related to the Shuttle/Centaur program, do you have any doubts concerning your ability to meet the schedule of launching both the Galileo and Ulysses missions in May, 1986? Do you have any "slack" time built into your schedule for contingencies?

Answer 19: Prior to undertaking the task of developing and producing the STS Centaur for launch in 1986, we fully recognized the challenges involved in meeting this launch commitment. While the schedule remains tight, we are firmly committed and believe we can meet the challenge. We are encouraged by the success to date in our development program at Sycamore Canyon and expect to complete these tests by late spring of this year. Production of the first two vehicles is essentially on schedule, and we have delivered to the Cape our avionics simulator, which is being used to verify the functional compatibility of the Centaur to the processing facilities. The software development, ground support equipment and launch complex are on schedule.

We do have "slack" time built into our schedule for the first production unit at the Cape. We have a 2 month storage period between processing at Complex 36, and prior to entering the vehicle processing through the STS facilities. Processing for the second vehicle is anticipated to take less time due to the learning process of having done it once. In addition, the normal work shift activity planned at Complex 36 and VPF is one shift. Usable slack time during these activities could be made available through multiple shifts and weekends.

Question 20: What are your current projections for the development costs associated with the Centaur-G and the Centaur-G-Prime configurations, compared to earlier cost projections? Likewise, how do the costs associated with modifications to Shuttle orbiters and modifications to Kennedy Space Center facilities for the Centaur compare to your earlier projections?

Answer 20: The current projections for the Centaur G and G Prime development costs are under assessment by a joint NASA/USAF team. The results of this assessment will be available late April 1985. We expect that the current NASA DDT&E total, reflected in the FY 1986 budget, of $248.8 million will have to be adjusted after the joint review team's final assessment.

The costs associated with the modifications required to the Shuttle orbiters and KSC facilities to accommodate the Centaur are still within the total costs reflected in our FY 1985 budget.

Question 21: What are the Centaur vehicle and launch costs for the first two planetary missions, Galileo and Ulysses?

What do these costs include?

Answer 21: The total costs, including funds requested in the FY 1986 Budget, for the first two Centaur G Primes for Galileo and Ulysses, is $194.0 million. Within these costs are two Centaur G Prime flight vehicles, two Centaur Integrated Support Structures (CISS), spares, tooling set-up costs, and all associated launch support, flight operations and post-mission analyses. The actual flight vehicles are about $40 million each, which reflect the first-time tooling costs. We expect that these figures will have to be adjusted after the joint NASA/USAF cost review team final assessment.

Question 22: Included in your budget is money for a Centaur avionics upgrade. What does this program provide?

Answer 22: One million dollars is in the budget for studying the requirements for upgrading Shuttle Centaur avionics. These funds will be used to investigate and examine improvements to the avionics system using modern design technology and components. The present Shuttle Centaur avionics system was designed in the late 1960's; therefore, the technology and parts are becoming obsolete, which means piece parts are becoming exceedingly more difficult and costly to procure. With the projected life of Centaur, continued usage of the original system could be uneconomic.

Shuttle Marketing Contract

Question 23: The award of the contract for NASA's new Shuttle marketing effort has slipped from the originally-scheduled date of mid-December 1984.

When do you expect to announce the winner of this competition?

Answer 23: From the current status of the Source Evaluation Board's deliberations, it should be possible to transmit the findings of the Board to the Source Selection Official by the end of March. The announcement is expected in April 1985.

Question 24: How do you expect this marketing effort to assist NASA in its head-to-head competition with Ariane?

Answer 24: The primary thrust of the assistance will be in the development of marketing and sales strategies advice to NASA.

NASA has specified in their Request for Proposals that the offerers must indicate the resources and technique that they will use to provide professional marketing advice and, how they would, in turn, help to implement that advice.

Question 25: Will this new Shuttle marketing effort compete directly against a U.S. ~~ELV~~ industry?

Answer 25: The new marketing contract is aimed at a head-to-head marketing contest with Ariane. The U.S. ELV entrepreneurs enter into the competition because they believe they can compete with Ariane. No matter the price for Shuttle flights in the future, Ariane will offer services priced below that of the Shuttle. This has been the experience, and it is expected to continue. Therefore, operators of the U.S. ELV's will have to contend with Ariane as their chief competitor, not Shuttle.

Thermal Protection Tiles

Question 26: Do you completely understand the thermal protection tile problem that you discovered on the Orbiter Challenger?

Answer 26: Extensive tests and analyses have shown conclusively that the Challenger tile problem was initiated by interaction of the tile waterproofing agent (DC 6079) with the underlying surface smoothing material referred to as screed (RTV 577). This interaction resulted in softening of the screed and tile adhesive material (RTV 560) leading to a loss of bonding strength. The precise chemical mechanism by which the DC 6079 waterproofing agent attacks the screed and adhesive material is still undergoing analysis; however, it is clear that the waterproofing agent causes the problem.

As an interim measure, we have reinstituted the use of a less effective but non-degrading rewaterproofing material in lieu of the DC 6079. In addition, the Orbiter is being protected by a rain shelter while on the launch pad at KSC.

As a long term solution, we are looking for a new waterproofing agent that does not react with the screed or tile adhesive materials.

Question 27: How confident are you that there will be no other such problems related to the tiles and that the Orbiter Challenger presents no safety concerns?

Answer 27: We are confident that there will not be a repeat of other such problems related to the tiles. The DC 6079 waterproofing/screed problem resulted from reliance on the similarity between the screed (RTV 577) and adhesive (RTV 560) material, during the certification process. There were subtle differences between the two materials which became important in the presence of a combination of environmental factors. The new waterproofing agent will be completely tested in combination with all elements of the tile system under all the environmental conditions it can encounter.

The Orbiter Challenger presents no safety concerns. All tiles which were affected by the DC 6079 waterproofing/screed problem have been removed and replaced.

Space Shuttle Main Engine (SSME)

Question 28: According to your written statement, you have two alternate contractors studying the Shuttle Main Engine with the goal of improving the Main Engine's life by applying alternative approaches and/or advanced technologies. When will the alternate contractors build and test this hardware and when will the decision be made to retain the incumbent contractor or to select a new contractor?

Answer 28: An alternate contractor will be on contract to start design and development of improved SSME components by early FY 1986 with full scale component testing to start in early FY 1988. Testing of prototype full scale components on a test bed SSME will follow.

The current intent of the alternate contractor utilization is to develop product improved components with longer life, thus providing more cost effective flight operations. If, and when, this is accomplished, the alternate contractor will produce and supply these improved rocket engine components for engine ground testing and potential introduction into the fleet of flight engines. There is no plan to replace the incumbent contractor who is presently developing improvements to the SSME, and will continue to produce the SSME and spares, and provide flight support.

Question 29: After having spent over $2.7 billion developing and procuring the present Space Shuttle Main Engine configuration, NASA decided last year to embark on a new program to improve the reliability and cost effectiveness of the Engine. What assurances are there that significant improvements in the life of the Engine can be obtained by spending even more than the $2.7 billion already spent? What are the likely costs associated with this program and any related development costs?

Answer 29: During the past two years there has been a development program at Rocketdyne aimed at improving the SSME in terms of increased life and hence decreased operating costs. The development, divided into two parts, has concentrated in the near term (Phase II) on the high pressure turbopumps and in the longer term (Phase II+) on improving the hot gas flow, by redesign of the hot gas manifold. The Phase II pump development is virtually complete and has been very successful. It is expected that the recently initiated certification testing will demonstrate that the life of the fuel pump has been at least doubled. There will be a significant return (2-3 to 1) on the pump development costs over the next ten years through reduction in maintenance and overhaul costs.

The longer term Phase II+ development is expected to be completed by the end of FY 1987. The focus of the Phase II+ effort is on increased operating margins and hence increased safety, but also there is expected to be a positive effect on engine life.

In addition, NASA has embarked on a SSME competitive engine study to produce a better and a more cost effective product. The goal of the program is to acquire longer life and improved performance of the engine components. Engineering cost studies now being performed by Aerojet and Pratt and Whitney have identified several component improvements that are cost effective. These studies will be completed by October 1, 1985. In a planned follow-on effort, one of these contractors will be selected to produce and test component prototype hardware. The cost of this program is projected in FY 1986 to be $230 million through FY 1990.

Several years ago, a SSME type engine technology advancement program was jointly established between OSF with OAST. The objective of this effort is life enhancement and performance improvement in combustion devices, critical turbomachinery components (bearings, seals, etc.,) rotor dynamics, diagnostic techniques and improved materials. Some of the new technology from these activities has matured to the point where it is being incorporated in the product improvement effort previously described. A good example of progress on this technology program is the development of improved high temperature single crystal material turbine blades. These blades have been tested in the laboratory up to an equivalent 72 mission cycles without exhibiting cracking, compared to the every 5-6 mission change out required of present turbine blades. This engine technology program is included in the FY 1986 Budget runout through FY 1988 at approximately $12 million per year. These efforts provide a technology base for future launch vehicle engines.

In conclusion, the technical progress and outputs of these programs are providing strong assurances that significant extended engine life and major cost savings can be achieved in the SSME program.

Orbital Maneuvering Vehicle (OMV)

Question 30: How will operational costs for the OMV be handled? Will NASA consider assessing user fees for OMV assistance to commercial customers?

Answer 30: Initial disucssions have been held internally relative to an OMV use pricing policy but that definitive policy is design configuration dependent, which will be decided at time of selection of the Phase C/D (flight development) contractor. Specific configuration factors such as OMV length and fuel and oxidizer replenishment will be the key, as well as the nature of the missions, i.e., long burn vs. short burn related to engine life, etc.

Question 31: How, if at all, will DoD participate in or contribute to NASA's OMV development? What is the likelihood that DoD will build its own version of the OMV?

Answer 31: The DoD is currently assessing what utility the OMV might bring in support of National Security missions. DoD has funded an assessment task in NASA's definition phase contracts which are in progress. Results of these assessments may be available in late summer or early fall, after appropriate DoD reviews. Civil applications relative to generic satellite servicing functions, including deployment and retrieval, should be useful for DOD applications as well. Whether DoD would build its own OMV capability, if required, acquire a modified NASA OMV, or use the NASA capability on a reimbursable basis, is not known at this time.

Solid Rocket Motors

NASA is conducting a study effort to determine second source interest and viability in the production of the Shuttle's Solid Rocket Motors.

Question 32a.: What criteria, and their relative weights, will determine if a Request for Proposal is released soliciting a second source?

Answer 32a.: The determination if a Request for Proposal is released soliciting a second source will be made after an assessment of:

1. Second source management interest and corporate capability.

2. The viability of the estimated costs to the government including the amortized cost of facilities, tooling/equipment and qualification.

3. The impact of a split buy on Morton-Thiokol's production costs.

4. The bottom line long term savings (or costs) to the government.

Although, no weighted criteria have been established for making a determination, the primary consideration in releasing a solicitation for second source is to realize a cost savings to the government.

Question 32b.: Could you compare the costs to date associated with development and production of the Solid Rocket Motors with the earlier projected costs?

Answer 32b.: NASA is in the process of evaluating the viability of a second source for production of Solid Rocket Motors (SRM). It would not be prudent, in our opinion, to discuss SRM cost at this time.

The original commitment based on the December 1972 Shuttle program work breakdown structure for the development of the Solid Rocket Booster Program, which includes the SRM's, was $390.0 million in 1971 dollars. This amount included design, development, testing and evaluation, and the production of six flight sets to support the Development Flight Test Program. At the completion of the Flight Test Program, comparative cost in 1971 dollars amounted to $387.0 million which included four instead of six development test flights.

For a FY 1986 flight, the refurbishment and production of an SRB flight set is estimated to average $29 million (FY 1986 dollars). For comparability, the February 1982 pricing study utilized to establish the price for FY 1986 launches estimated these costs to be $32 million (FY 1986 dollars).

Question 32c.: Why did NASA not initially establish a second source for the Solid Rocket Motors?

Answer 32c.: Shuttle program planning has always included the desire to qualify a second source for the manufacture of the SRM and having an "education" buy prior to competing the production buys beginning with the third increment procurement at the earliest. Any decision to proceed with a second source initiative would have to be made following an assessment, as currently being made, that establishing a second source would result in savings to the government. The two primary factors which have up to now delayed initiating any second source action were the instability of the flight requirements and the immaturity of the SRM production documentation.

The third increment buy procurement calls for procurement of 60 flight sets which would be delivered through the first quarter FY 1989. This is considered sufficient time to qualify a second source if such a decision were made by this summer. The fourth increment buy would thus be the earliest SRM procurement which could include a second source split buy.

Question 32d.: To what extent would NASA be willing to absorb any additional costs associated with the establishment of a second source?

Answer 32d.: The primary factor in a determination to proceed with a solicitation for a second source is the bottom line savings (or cost) to the government. This bottom line will include the amortized costs and present worth analysis of the costs to NASA of facilities, tooling, and qualification and the production inefficiency of production start-up of the second source, as well as the next impact of a split buy.

QUESTIONS OF SENATOR HOLLINGS AND THE ANSWERS

NASA DOD Issues

In the course of the last year, there has been much discussion about the Shuttle facility at the Vandenberg Air Force Base (VAFB).

Question 1: Would you please give the Committee the current status of this activity and an indication of when VAFB will be operational?

Answer 1: Recently NASA and DoD jointly agreed to postpone the first VAFB launch from October 15, 1985 to no earlier than March 20, 1986.

This decision was based primarily on the importance of maintaining the current Shuttle manifest and to insure adequate margin in the development of the DoD payload for the initial Vandenberg launch. All required facilities are expected to be defined as operational by the end of this calendar year (1985).

During February and early March of 1985, Orbiter OV-101, inert SRBs and a flight ET were processed through the VAFB facilities and stacked on the pad to verify the interfaces. This verification has been completed and the "facility verification vehicle" is in the process of being disassembled and removed from the launch pad.

Question 2: What is DOD's projected Shuttle flight rate at the VAFB Shuttle facility? Does NASA intend to dedicate an Orbiter for use at VAFB? What polar orbit Shuttle requirements exist for NASA in light of NOAA's decision to launch NOAA-K, L, and M with Titan IIs?

Answer 2: NASA does not intend to dedicate an Orbiter for use at VAFB. The four-Orbiter fleet will be used appropriately, and as necessary, to meet DOD and other customer requirements for space launch services.

NASA's current planning anticipates a capability at VAFB of 4 flights per year. The latest DOD estimates incorporated in NASA planning are for 2 flights in FY 1986, and 3 flights per year starting in FY 1988. These flights are augmented by 1 flight per year starting in FY 1988 for NASA and other civil government requirements. NASA polar orbit requirements consist of continued scientific research in the high inclination regime to study the Earth's radiation budget, to research the origin of plasma in the neighborhood of the earth, to study solar physics in sun-synchronous orbits, to launch and maintain various earth environment monitoring spacecraft such as LANDSAT. NASA will continue to support NOAA and other agencies with research and development of techniques to acquire data from space supporting the activities of the interested agencies or departments of the U.S. government.

Question 3: What are the conditions of the current Space

Shuttle Program quid pro quo agreement that NASA has with DOD? Is NASA getting its fair share from this agreement? Is it true that the DOD's advantage in this agreement was $409 million in 1982 and $900 million in 1983? What was the advantage to either party in 1984?

Answer 3: The quid pro quo portion of the NASA/AF Pricing Policy MOA calls for the following:

1) DOD shall provide standard launch support services for all non-DOD payloads and missions flown from VAFB.

2) NASA shall provide standard launch support services for all DOD payloads and missions flown from KSC, as well as mission operations costs at JSC.

3) DOD does not pay NASA for any Shuttle related NASA Center manpower supporting DOD launches. In return, NASA does not pay DOD for Shuttle related DOD manpower, supporting a civil launch.

The quid pro quo has not become fully operational, since VAFB is not yet operational.

There was no advantage to either NASA or the DOD in FY 1982, 1983, and 1984. The first DOD Shuttle mission was flown from KSC in FY 1985, and, as noted, VAFB is not yet operational.

Question 4: It has been suggested that NASA charge DOD a "standby charge," at least equivalent to NASA's non-recoverable expenses incurred in scheduling and preparing for a flight. What is NASA's position toward this proposed pricing change?

Answer 4: NASA and DOD are jointly developing a pricing policy for DOD flights that provides a positive incentive for flying on the Shuttle. The pricing policy will be based upon the principle that an agreed reimbursement rate per flight will be comprised of a fixed and variable component, resulting in an annual fixed fee and a charge per flight at marginal or incremental costs. The base flight rate for this pricing approach will be consistent with the DOD's commitment to utilize at least one-third of the STS flights available during the next ten years, and a target flight rate of 24 per year.

Question 5: NASA and the Air Force are to submit a report to the Armed Services Committee concerning the requirements and concepts for future heavy lift vehicles (HLVs).

What is the status of the NASA Air Force activity? When will this Committee be briefed as to the results?

Answer 5: This report addressed the growth potential of CELV candidates to ensure that the near-term selection would provide an evolutionary capability to meet anticipated future requirements.

NASA, OMB, and DOD participated in the preparation of a report, Complementary Expendable Launch Vehicle Report to

Congress, which was submitted to the Congress on behalf of the Administration by Secretary Weinberger on February 28, 1985. Further longer-range joint studies, not linked to the CELV issue, are contemplated.

Orbiting Maneuvering Vehicle (OMV) New Start

The FY 1986 NASA Budget Request includes $25 million for an Orbital Maneuvering Vehicle -- the only new start included in the NASA request.

Question 6: What is the current status of the OMV Phase B definition activities? If this "new start" is approved, when would the RFP for the OMV be released?

Answer 6: The OMV Phase B definition studies by three separate contractor teams were initiated in September of 1984, are now undergoing extensive mid-term reviews. They will be completed in August of 1985. The Phase C/D (Flight Development) RFP is planned for release in September of 1985, with projected award and start in the spring of 1986.

Question 7: Would you please give the committee an estimate of the total cost of the OMV? When would the OMV come on line? Would projected life-cycle, costs be an evaluation criteria in an OMV RFP?

Answer 7: The estimated cost for the OMV development and first flight unit is $375-450 million. The OMV would be available early 1990. The evaluation criteria for OMV Phase C/D RFP has not yet been established, and projected life-cycle costs of proposed vehicle configurations certainly could be a consideration in the criteria.

Question 8: Is the OMV meant to be Shuttle compatible, Space Station compatible, or both? Is the OMV to be based in space or will it be returned by the Shuttle after each mission? Could you please identify the missions that necessitate the development of an OMV at this point in time? Why isn't the existing Shuttle capacity suitable for projected retrieval, repair, refueling and reboosting activities.

Answer 8: The OMV is configured to primarily deliver or retrieve payloads to or from the STS in orbit for servicing. This OMV will normally return to Earth after each flight operation with the STS. It can be left in orbit for about 9 months, in a dormant mode, for reuse in subsequent Shuttle launch operations when this operational mode is more appropriate.

We are coordinating our OMV planning closely with the Space Station program. We understand the Space Station program plans include a second OMV (funded by their program) that would be based at the Space Station for operation in that orbit region. This second OMV, which would also be compatible with STS launch/ operations, would have its operational capability affirmed by the earlier STS based OMV experience. The basic design configuration of the first OMV is being "scarred" so that later Space Station OMV configuration requirements can be incorporated in the second vehicle with minimum impact.

There are several reasons for "why development of the OMV now?" The OMV is a critical element in future utilization of the full operational capabilities of the STS. The OMV is a reusable, remotely piloted vehicle that increases the "reach" of the STS by moving payloads to and from the STS. It moves these payloads under ground control, freeing the Shuttle crew to perform other operations during payload transportation to/from the STS. It eliminates the need for STS energy and crew time in making these local stops. The OMV can, for reference, move a 5,000 lbs. satellite in a roundtrip orbit altitude change of about 1200 nmi. or effect about a 7 degree orbit plane change, so it has quite a large orbital maneuvering capability.

The primary use of the OMV will be in bringing satellites to the Shuttle (or later Space Station) either for servicing by the crew or return to Earth. In particular, the OMV is expected to play major roles in the Hubble Space Telescope (HST), Advanced X-Ray Facility (AXAF), future Earth observation, communications, and science spacecraft. Our recent success in saving three satellites, along with the logically expected increase in these mission operations that success brings, strongly supports a need for additional capability to bring and return future servicing "customers" to the STS.

This is particularly true in polar orbit operations, where we will soon be operating through Shuttle launches from its Western Test Range (WTR). The Shuttle has much less payload capability from the WTR, since the rotation velocity of the Earth (available in the ETR equatorial orbit launches) is not available. The OMV will efficiently increase the orbit payload delivery/retrieval capabilities of the STS for polar orbits.

The OMV also permits future launch of payloads from the STS without their own propulsion/fuel systems, thus allowing for reduced satellite cost. Some payloads, such as our potentially promising commercial materials processing application, do not want integral fuel tanks due to "slosh" perturbation; yet want periodic removal of products and resupply of materials. The OMV will perform these operations from the STS beginning in 1990 and be fully checked out to serve a major role with the STS in construction of the Space Station.

The STS capability is excellent for placing large payloads in (150-160 nautical miles circular orbit) or special circumstances a dedicated direct insertion orbit to higher altitudes in an elliptical orbit. For rendezvous and subsequent reboost, the orbital dynamics do not permit achievement of altitudes originally acquired in direct insertion. The OMV extends the STS reach for retrieval, placement, and servicing.

Question 9: The Space Station configuration that has been devised by NASA assumes two OMV's.

Would you please indicate whether or not, two OMV's are planned? Will they both be funded by the Office of Space Flight?

Answer 9: There are two OMV's planned. The OMV development and one flight unit, which is STS based, is separately identified in the FY 1986 President's budget request, and will be funded by the Office of Space Flight. The initial OMV will be "scarred" for later Space Station on-orbit operations requirements to permit smooth transition. The first OMV will assist the STS in the early Station assembly operations. The second flight unit is planned in Space Station funding estimates and will be orbitally based.

Question 9A: Is the second OMV incorporated in the Space Station $8 billion budget plans?

Answer 9A: We understand from discussion with Space Station Program management that the second OMV is firmly incorporated in their program plans and included in their budget. The OMV provides "reach" for the Station and is, therefore, probably quite important to them.

Question 10: Finally, a recent article in the Journal of Commerce discusses a new West Coast firm, SpaceCab (Space Cabotage Navigation Co.,) that will become operational in 1992. The company would recover misdeployed satellites and other debris.

Are you familiar with SpaceCab, and is there any potential for commercial development of a "space tug?" Would the availability of a commercial space tug negate the need for a NASA OMV? For example, could NASA lease the services of SpaceCab or any such firm in a manner comparable to that in the RFP for space platforms?

Answer 10: We are not familiar with SpaceCab, and they did not bid on our OMV Phase B (A-109 system acquisition) RFP. Risking our large observatory class facilities to retrieval and reboost with design configurations that we do not control, certify, and test, is not considered prudent. There aren't enough currently defined missions, without the Government's guarantee of a certain number of flights per year, to assure a reasonable payback, and so, no commercial offers have been made to us.

Shuttle Centaur Upper Stages

There has been much discussion recently about the Centaur G, and G Prime upper stages, and I have submitted several questions to Mr. Beggs that should clarify the situation. However, there is another issue concerning the Centaur upper stage -- the RTG issue -- that is not frequently discussed (radioisotope thermoelectric generators).

Question 11: Would you please give the Committee a brief description of the RTG issue, including a brief discussion of what makes this proposed use of plutonium in space different from past uses?

Answer 11: The RTG issue associated with the Centaur Upper Stage launches of the Galileo and Ulysses deals with the assurance that the probability of a nuclear fuel release due to a Shuttle launch accident does not exist or is negligible. The only difference between the use of nuclear fueled power sources on previous missions with the planned Galileo and Ulysses missions is the possibility of a severe explosive environment associated with a Shuttle launch accident; this concern is due to the quantities of propellant and the closer proximity of the RTG's to the possible explosive sources. However, it should also be noted that the probability of an accident with the man-rated Shuttle is much lower than it is for Expendable Launch Vehicles.

Question 12: What is the current status of the DOE/NASA review of this issue? Could this issue effect the scheduled launch of the Galileo and Ulysses missions?

Answer 12: The most recent analysis, conducted by the Johnson Space Center, indicates much lower accident probabilities with the Shuttle/Centaur than the Titan/ Centaur used in previous RTG launches. In addition, recent RTG shock tube tests have shown better than expected resilience of the fuel containment system to survive explosive environments. Therefore, we believe that the RTG issue will be resolved satisfactorily, and will not affect the launches of Galileo and Ulysses missions.

Question 13: Do you agree with the recommendation of the Aerospace Safety Advisory Panel that the prime responsibilityto obtain a flight clearance for the RTG should rest with the Jet Propulsion Lab?

Answer 13: NASA agrees with the recommendation that the prime responsibility for obtaining flight approval for the RTG's should rest with JPL.

Question 14: Why doesn't NASA conduct a "flight test" prior to the launch of the Shuttle Centaur upper stage? Was a "flight test" option ever considered in this program? What are the reasons why a "flight test" is not undertaken -- cost, time constraints, technical certainty, etc.?

Answer 14: The Shuttle Centaur is derived from the flignt proven Centaur D-1A and Centaur D-1T vehicles. These configurations have had a high success rate to date. Integration of the flight proven Centaur into the STS is being accomplished with minimum modifications to Centaur. The structural/fluid interface of this upper stage to the Orbiter is provided by the Centaur Integrated Support System (CISS). The CISS remains with the Orbiter after Centaur deployment. Prior to the first flight, we will have verified the functional compatibility of the Orbiter and its interface with the Centaur. Extensive ground testing is planned at the launch site prior to each mission to increase our confidence in accomplishing these missions.

Therefore, the benefits derived from such a "test flight" would not justify the significant cost and schedule impact of performing the "test flight."

Budget Reduction Options

The Congressional Budget Office has proposed a 10 percent reduction in the Office of Space Flight "operational budget" as a cost saving initiative in the FY 1986 Budget.

Question 15: Would you please comment on CBO's "representation" of this option and the consequences, if any, to the Space Shuttle program?

Answer 15: The following tables reflect NASA's FY 1986 Budget planning for Shuttle Operations:

	FY85	FY86	FY87	FY88	FY89	FY90
TOTAL SHUTTLE FLIGHTS	10.0	14.0	17.0	19.0	24.0	24.0
NASA	3.8	6.7	7.8	6.1	7.2	9.3
DOD	2.0	2.3	5.7	8.0	10.3	8.3
FOREIGN & COMMERCIAL	4.2	5.0	3.1	3.6	5.0	5.2
REFLIGHT OPPORTUNITY	-	-	.4	1.3	1.5	1.2
TOTAL SHUTTLE FUNDING	1832	2138	2325	2461	2534	2681
NASA APPROPRIATION	1314	1725	1459	1283	1372	1456
DOD	330	155	531	771	647	732
FOREIGN & COMMERICAL	188	258	335	407	515	493
CBO PROPOSED SAVINGS	-	260	260	260	270	280

In responding to the CBO proposal several points need to be made.

1. Shuttle Operations involves a large amount of relatively fixed costs which are a function of achieving and sustaining the capability necessary to conduct Shuttle mission rather than the specific number of missions flown.

2. Total funding requirements for Shuttle Operations include the NASA appropriation and reimbursements received from the DOD and foreign and commercial customers.

3. The price charged commerical customers exceeds the marginal cost to fly these missions. This means that a portion of the price paid by foreign and commercial customers is used to offset the fixed Shuttle Operations funding requirements. A reduction in foreign and commerial customers would actually increase Government funding requirements.

4. NASA funding requirements would increase with a reduction in DOD flights in a manner similar to the impact of reduced commercial flights, since they also reimburse NASA more than the marginal cost of a flight. However, the overall Government funding requirements could be reduced by decreasing the number of NASA or DOD missions, provided they are not flown by other means.

5. In the long run approximately $50 million can be saved by dropping a Shuttle flight assuming sufficient time is provided to adjust production and operational activities. This cost reduction is spread over three years with the largest portion being in the year of launch.

6. Due to contracting incentive arrangements and lead times with the major hardware suppliers, the savings in the near term will be less than the $50 million.

Because NASA projects the price it charges foreign and commerical customers to exceed the costs of providing flight services, the budgetary savings of lowering the flight rate would be realized only if the U.S. Government were to cut back its own flights, rather than those supplied for foreign and commerical customers. We believe that approximatley $250 million per year could be saved if government missions were reduced by five per year starting in FY 1987 and they were not flown by other means. (Because of the contracting arrangements and the three year time phasing of the savings, the FY 1986 savings would be substantially less, approximately $120 million.) This would entail a reduction in planned Government flights by a factor of one-third.

The CBO report points out that the Shuttle system represents a large public investment that has just begun to pay off. The ratio of fixed to operating costs is very high, and therefore a disproportionate increase in services can be obtained with a relatively small percentage increase in costs. The specific impact would depend on the distribution of the flight reduction between NASA and the DOD, however, it is our belief that reductions of this magnitude could impact the NASA science programs.

Question 16: Is it true that two-thirds of the Shuttle's operational costs are "fixed," regardless of the number of flights? Shouldn't the fixed costs bear some relationship to the number of planned flights?

Answer 16: Two-thirds of Shuttle operational costs are fixed for the number of Shuttle flights being considered through the late 1980s and early 1990s, or for about 24 flights per year. Fixed costs depend on capability that has been provided as well as the timeframe in which the flights are conducted. Once the flight rate capability is established for a higher level of flights, and the system is planning on having to meet the higher flight rate capability in a subsequent period, the fixed cost requirement, is not significantly affected by an incremental change in the current flight rate. The capability in manpower, facilities, etc. does not vary for flight rates of these magnitudes. If the overall flight rate were to be reduced on a substantial basis or increased to exceed the manpower and facility capability, necessitating an augmentation of service contracts and existing facilities, then the fixed costs would change.

Question 17: Could you please give the Committee an indication of what "fixed costs" are and a breakdown of what items are included in this term? How do the FY 1985 fixed costs compare to the actual fixed costs in the FY 1984 Budget and the projected fixed costs for FY 1986?

Answer 17: Fixed cost requirements are those that do not change as moderate fluctuations in flight rate are experienced. The following are examples of fixed costs: Launch facilities, mission control facilities, training facilities, facility maintenance spares and logistics support, software maintenance, repair facilities, operations infrastructure, secure facilities, range safety and space tracking. Examples of variable costs are: Propellants and gases, other consumables, expended items such as the External Tank and parts of the Solid Rocket Boosters, replenishment spares, production items experiencing manufacturing rate effects (learning), and the broad category of Shuttle turnaround subject to learning. The fixed costs have been and are anticipated to remain relatively constant through the 1986-1990 timeframe.

Question 18: What would be the effect of the CBO option on NASA's Shuttle pricing policy? Would a scale-back in the number of Shuttle flights be advantageous to commercial ELV operators? What would be the effect of the CBO option on NASA space science and applications payloads and commercial JEAs flight opportunities?

Answer 18: The CBO report of March 1985 examined various pricing options for the STS. NASA is in general agreement with the CBO analysis of these options and the policy implications presented in the report, Summary XIII. It is highly doubtful, however, that STS price along would guarantee a viable commercial ELV industry. Although a "low" Shuttle price could impact the commercial ELV ability to compete, a "high" Shuttle price would not guarantee they would be viable. A scale-back in the number of Shuttle flights would be most advantageous to Arianespace which has already captured 50 percent of the communications satellite launch market over the past fourteen months. NASA believes that they will have, or can readily obtain, sufficent launch capability to satisfy a dominant share of the market for which commercial ELV operators can compete. Arianespace's launch experience and aggressive discount pricing policies provides them a great competitive edge over newly created U.S. domestic commercial ELV operators. NASA space science and applications would probably not be affected greatly by a decreased Shuttle launch rate. However, commercial interests in JEA's would likely be lessened with reduced Shuttle availability.

"Fencing" the Shuttle Program

There has been much discussion about "fencing" the Shuttle Program.

Question 19: Would you please give the Committee the origins of the "fencing" concept and explain briefly what the concept means? What is the status of the Shuttle Operations Strategic Planning Group, and when will the Committee receive its recommendations?

Answer 19: The origin of the "fencing" concept stems from recommendations made to the Administrator by the NASA Advisory Council (NAC) based on perspectives they gathered in late 1982 and early 1983, which were contained in their report: "Study of the Mission of NASA," dated October 1983. The concept offered by the NAC was that there should be a discernable, structured segregation of the Shuttle operations program elements within NASA and identified by separate budget line, funding allocation, funding control, aggregation of cost, cost accountability, and separate organization design, setting, and management control. NASA's assessment of the NAC recommendations is contained in our "Report to Congress on Shuttle Operations Fencing," sent to Congressman Fuqua on February 26, 1985.

The Shuttle Operations Strategic Planning Group, chaired by Mr. E. Smylie, has reported to the Administrator and their report will be provided to Congress shortly.

Question 20: Would you please give the committee a summation of the discussions between NASA and Astrotech? What were the "sticking points" in these negotiations? Is it too premature to consider commercial involvement in the Shuttle Program? What about foreign involvement or support of the Shuttle Program as a condition of participation in the Space Station Program?

Answer 20: NASA and Astrotech International Corporation have engaged in several discussions over the past 12 months regarding Astrotech's interest in making a capital investment in the Space Transportation System. Over that period of time, Astrotech has submitted for NASA's consideration and analysis "Terms and Conditions" reflecting two separate concepts Astrotech has developed to serve as a basis for possible subsequent agreements with NASA.

NASA has rigorously analyzed each of these two concepts and briefed Astrotech on the results of its analysis. Astrotech fully agrees that the NASA analysis demonstrates the extent to which the Astrotech Terms and Conditions in each case were not in accord with elements of NASA's Commercial Use of Space policy and broad NASA guidelines regarding potential private sector capital investment in STS.

Accordingly, NASA's discussions with Astrotech have never been raised to the negotiation level. Astrotech is currently developing another concept for NASA's consideration.

Given the long-lead times associated with Shuttle-based commercial space ventures, it is not premature to consider commercial involvement in the Shuttle Program.

There has been foreign involvement in the Shuttle Program. Two examples are the Canadian Remote Manipulator System (RMS) and the European Spacelab programs. Foreign involvement or support of the Shuttle Program is not a condition of participation in the Space Station Program.

Question 21: There has been much discussion of the "operational" nature of the Shuttle. Frankly, this operational representation is partially to blame for the rush to privatize or commercialize the Shuttle.

Is the Shuttle "operational" or is the Aerospace Safety Advisory Panel correct when it advises NASA management "to avoid advertising the Shuttle as being 'operational' in the airline sense when it clearly isn't?

Answer 21: A definition of "operational" is being documented in a joint NASA/DOD response to the President's request in NSDD-144. This definition is not intended to advertise the Shuttle (STS) operational capabilities in the same sense as an airline's operational status and thereby should prevent any further mis-perceptions.

By this definition, "operational" means that the STS is ready and available for routine use in the intended operational environment to achieve the committed objectives. This means that critical performance capabilities have been verified by flight demonstra-tion; that adequate logistic support for the system is in place; that ground and flight support capabilities are adequate to support the committed flight schedule of up to 24 flights per year with margins for routine contingencies attendant with flight rate capabilities; and that the appropriate operational management capabilities are in place.

Orbiter Spares Program

In the FY 1986 Budget Request, approximately $467 million is included for spares -- Orbiter Spares ($335 million), Engine Spares ($88 million) and Ground Support Equipment Spares ($45 million).

Question 22: Would you please give the committee a brief description of these various requirements and an explanation of why there is not one separate account for the spares program.

Answer 22: The FY 1986 NASA budget request of $490 million for spares is made up of the following elements: Orbiter spares ($335 million), Main Engine spares ($111 million), KSC GSE spares and repairs ($26 million), External Tank operational spares ($2 million), and crew equipment spares ($17 million).

Orbiter spares consists of lay-in/rate spares ($97 million), flight spares ($118 million) and structural spares ($120 million). The lay-in/rate spares are the initial spares required to support the planned 24 per year flight rate. Included are line and shops replacement units, logistics support to analyze requirements and procure spares, and the acquisition of maintenance test equipment to support depot maintenance. Orbiter flight spares includes replenishment of line and shop replaceable units, the repair and overhaul of flight units, and the manpower for supporting logistics operations. Structural spares are being procured to support potential damage to an Orbiter, as well as maintaining an option for a fifth Orbiter. Included are major elements such as wings, vertical stabilizer, crew module, payload bay doors, and AFT thrust structure.

Included in Main Engine spares are test spares ($9 million), production spares ($49 million), replacement spares ($26 million), and five (5) spare engines ($27 million). The test spares support the ongoing engine test program while the production spares support the production program, as well as serving as initial lay-in spares. Replacement spares are the line and shop replaceable units required to support the planned flight program as are the five (5) spare engines.

KSC GSE spares ($26 million) include replenishment spare equipment and repair manpower for all of KSC ground handling and support equipment required for the current and anticipated flight rate at KSC. Examples of this GSE are crawler shoes for the mobile launcher platforms, SRB hold down posts, and tail service masts components for use on the launch pads, valves for hydraulic systems, fuel and oxidizer pumps for fight and base propellants, and magnetic tapes for use with the Launch Processing System. Manpower for spares provisioning and repair is provided by the Shuttle Processing Contractor.

External tank operational spares ($2 million) provides the logistics spares and expendable hardware required to support the planned flight rate at the launch sites.

The crew equipment spares ($17 million) support the on-board non-orbiter equipment such as EVA tools, cameras, and the extravehicular mobility units (space suits).

Currently the design centers (i.e., Johnson Space Center for the Orbiter, Marshall Space Flight Center for the main engine, etc.,) have the logistics responsibility for their individual element of the Shuttle program. NASA has decided that the program and budget responsibility should reside in the same area and, therefore, there is not one central spares account. It is possible that in the future as the logistics responsibility is centralized, there will be a separate account for the spares program.

Question 23: What are the projected costs of the spares program for the next five years, and what is the relationship of the cost of this program to the scheduled number of flights?

Answer 23: The projected cost for the spares program for the next five years is $1,572 million, at a rate of $490 million in FY 1986, declining to $250 million per year in the FY 1989/1990 period. These estimates include Orbiter, main engine, and other program element spares. All elements of the spares program are funded to support a maximum 24 per year flight rate.

Question 24: Would you please give the Committee an update on the Logistics Support Contract activity?
Does the program include all three spares programs?

Answer 24: The prime contractor for Logistics Support for the Orbiter Project is Rockwell International. In an effort to consolidate our Orbiter repair activity, a Rockwell Service Center facility has been developed by Rockwell and is scheduled to open in March 1985, near KSC. Additionally, we are studying the use of the White Sands Test Facility and/or KSC as the repair depot for our fluid components (valves, regulators, pumps, actuators, etc.,). Contract activity for the Space Shuttle Main Engine (SSME) logistics will remain with the OEM (Rocketdyne). The External Tank contract is with Martin Marietta and our logistics system is largely embodied in the basic production line. Logistics contract support for the SRM/SRB by Morton Thiokol and USBI, respectively, is embodied in the basic refurbishment concept in which spares are readily drawn from production assets.

NASA has only one spares policy (program) which encompasses all NASA Space Shuttle projects. Although each project is somewhat independent, we are continuing our efforts to consolidate logistics management at the Kennedy Space Center. The transfer of all Ground Support Equipment (GSE) is planned to be completed by October of this year and all Flight Hardware is planned to be at KSC by 1988.

Question 25: In your testimony, you indicate that the structural spares program provides a set of components in case of damage to an Orbiter.

Can structural spares really be used as "replacement" parts?

Answer 25: The structural spares program includes such elements as wings, vertical stabilizer, crew module, payload bay doors, and aft thrust structure.

Each of the components we have on order can be used as replacements for damaged vehicles in the current fleet; however, the degree and location of the damage would determine the complexity and the time required to perform these replacements. Additionally, a component of a structural spare module can be used for isolated damage to one of the operational vehicles.

In the past, there has been much discussion of the "cannibalization" of parts that takes place in the Shuttle program.

Question 26: Has the spares program remedied this situation? What is the current "on the shelf" availability of Orbiter repair parts? When will there be 100 percent availability? Will NASA meet its commitment to have a spare engine available for every Orbiter in the fleet by the end of FY 1985?

Answer 26: Yes, improved spares availability is reducing the number of cannibalizations. The Orbiter fill rate has been averaging --- 86 percent the last three months of 1984, (KSC 78 percent + RI Downey 8 percent). The initial lay-in of spares will be completed by April 1986...sized to 90 percent on site (at KSC) logistics support capability. Some "out of stock" conditions will always exist, however, due to higher than planned consumption of individual line items. It is prohibitively expensive to attempt to purchase logistics support capability to 100 percent.

At the end of FY 1985 there will be spare engines available to support the flight manifest. That spares posture will continue until the 3rd quarter of FY 1986, when we will have a spare engine for all Orbiters.

Pricing Policy

Shuttle pricing policy is one of the most critical issues to be debated this year. However, there are two additional pricing policies that merit consideration because of their ability to stimulate interest in space-related activities — Spacelab pricing policy and hitchhiker pricing policy.

Question 27: Would you please give the Committee the current pricing policy for Spacelab and Hitchhiker? Will these policies be periodically reviewed?

Answer 27: The Hitchhiker Program is in its development phase and operational cost estimates are just beginning to be accumulated. The Hitchhiker Pricing Policy is being developed concurrently with the operational cost estimates.

At present, the Spacelab Pricing Policy is in the concurrence cycle for approval by NASA management and the Office of Management and Budget. We will provide copies when available. Once the pricing policy has been approved and implemented, it will be reviewed periodically.

Shuttle Manifest Problems

There has been much discussion in the trade press about the inability of certain types of payloads to gain access to the Shuttle. There also has been released a report by the Shuttle Science Working Group that promotes more frequent flight opportunities for the science and engineering communities.

Question 28: What activities are the Office of Space Flight engaged in that will insure more frequent access to space for NASA payloads, especially small and intermediate class payloads? Why doesn't NASA dedicate two or three Shuttles per year to flying NASA payloads, especially in light of NASA's manifest problems?

Answer 28: NASA has a number of missions per year called dedicated Spacelab missions available to customers, but it is often more opportunistic and worthwhile to fly with mixed cargoes. The Office of Space Flight has several initiatives underway to develop carriers that simplify or standardize the interface with the Shuttle. Carriers such as the Multi-Purpose Experiment Support Structure ---(MPESS) and two types of "Hitchhiker" accommodation provide additional opportunities to fly the Shuttle. These carriers can be integrated in minimum time and can provide more opportunities to fly valuable science payloads.

When the flight rate reaches 15 to 24 per year, there will be a greater number of opportunities. In 1986, we will fly Ulysses, Galileo, and the Hubble Space Telescope and five other scientific missions.

Question 29: Is NASA doing anything to promote or facilitate flight opportunities for graduate students?

Answer 29: NASA has established the Space Flight Participant Program as a means to include private citizens on periodic Space Shuttle missions. The first Space Flight Participant will be selected from among the Nation's elementary and secondary school teachers. Eligibility requirements for subsequent flights have not yet been determined. The Agency is not doing anything at this time to promote or facilitate opportunities for graduate students. When subsequent eligibility requirements are announced, it is possible that certain graduate students might possess the appropriate backgrounds to be considered as Space Flight Participants.

Question 30: Is it true that NASA is currently considering implementation of a policy that would give "priority" payload status to any NASA payload that has been delayed for six months?

Answer 30: NASA is presently considering and is raising the priority of those scientific payloads (other than standby) that have been subjected to delays.

Orbiter Turnaround

The turnaround time for the Orbiter has been an issue of concern to this Committee, especially in light of its bearing on the Shuttle manifest. The original design goal for the Orbiter was a turnaround time of 10 days. However, the best performance, to date, is 53 days.

Question 31: Would you please give the Committee an indication of the current turnaround time for an Orbiter? What are the associated costs?

Answer 30: The original Orbiter design goal for turnaround within two weeks or 10 workdays had to be traded off in favor of flight performance and safety parameters. Turnaround times for each Orbiter have begun with long periods of over 100 workdays, and improved with modifications and recycles to the 53 workdays, for STS-41-C. NASA is continuing to make improvements to the Orbiters and facilities and expects to demonstrate the Orbiter turnaround goal of 35 workdays this year, 1985. This turnaround baseline consists of 18 workdays in the OPF, 4 in the VAB and 13 on the pad. We have achieved 26 workdays in the OPF, 4 in the VAB and 16 on the pad during different flow sequences. It should be noted, however, that these are Shuttle vehicle and/or Orbiter flow times and the addition of cargo serial testing, mission mods or launch window periods will result in a longer total cycle for manifesting purposes. The 35-workday turnaround should allow a launch rate of about 7 flights per Orbiter per year or 20 per year from KSC at 6 workdays per week. Our planning goal is to achieve a 28-day turnaround during the FY 1987-89 timeframe.

Turnaround activities at KSC are conducted by the Shuttle processing contractor with support from the base operations contractor and other support services. The cost requirements associated with this effort in FY 1985 and FY 1986 are approximately at $340 and $365 million, respectively, and provide for Orbiter vehicle processing, retrieval and stacking of the solid rocket boosters, processing of the external tank, mating and checkout of the launch vehicle and procurement of related hardware and ground support equipment. Not included in these estimates are costs of propellants, cargo processing or support to contingency landing sites.

Question 32: What are the projected turnaround times for the Orbiter fleet in 1987? 1989?

Answer 32: NASA is identifying additional Orbiter improvements to improve the near-term 35 workday turnaround to a target of 28 workdays in 1987 or 1988, and remain at about that level through 1988 and 1989. A 28 workday turnaround would allow about 21 launches per year from KSC at 5 workdays per week or up to 25 launches per year at 6 workdays per week with 3 serviceable Orbiters and the facilities now budgeted.

Solid Rocket Motor Integrity Program

In August 1984, the Committee was advised that NASA was undertaking institution of a Solid Rocket Motor Integrity Program to identify the cause of and solutions to the persistent solid rocket propulsion problems.

Question 33: What is the current status of the Solid Rocket Motor Integrity Program? How much money is included in the FY 1986 Budget Request for this activity? How much money is included in the FY 1985 Operating Plan?

Answer 33: The Solid Rocket Motor Integrity Program has been initiated. The Engineering Verification tasks (Phase I) are well underway. Exit cones are being examined to determine their physical and thermal properties. Technical plans for better understanding and characterizing the manufacturing process have been defined and accepted by the fabricator, the motor supplier and the stage supplier. A heavily instrumented motor was tested on December 20, 1984 and met all test objectives. This test produced initial engineering data to better understand the thermostructural behavior of the nozzle components, produced data for improving analytical tools, provided insight into the impact of the adhesives used in assembly, and provided insight into the exit cone select/reject criteria.

The Technology tasks (Phase II) are also proceeding well. Request for proposals covering nine tasks were issued on January 7, 1985 and evaluation teams are now selecting from among the 22 proposals received. These tasks are expected to be on contract early this Spring.

We have budgeted $4.0 million of FY 1985 funds for this activity. We are requesting $4.5 million for FY 1986.

Question 34: Was NASA successful in securing DOD and industry support for this activity?

Answer 34: Industry and DOD contributions and participation appear promising at this time. Significant amounts of data, manpower, and price reductions have been contributed by industry to date. The dollar value, exclusive of engineering data, has been estimated to be approximately $400 thousand. Significant additional contributions are anticipated for the Technology (Phase II) contracted tasks.

DOD contributions to date consist of savings ($300 thousand) when using DOD motor test facilities. Discussions with DOD personnel indicate a positive potential for additional contributions in the form of engineering support and/or resource support for a coordinated and integrated program effort.

Question 35: Will the information obtained pursuant to this investigation be quickly and widely disseminated to commercial and government contractors? When will the "findings" of this investigation be available?

Answer 35: Yes, the information obtained will be quickly and widely disseminated. Much of the work will, in fact, be done by commercial and government contractors. Results of the tasks will be available as each task in completed. A summary of the completed Engineering Verification task is scheduled for the second quarter of FY 1986. The Technology tasks will be completed by the end of FY 1987 with periodic reports disseminated to responsible government and industry organizations commensurate with the timing of the individual tasks. Annual reports of the Technology tasks are planned.

Question 36: Does NASA intend to establish a "certification" program for commercially developed upper stages?

Answer 36: NASA does not now intend to establish a formal program for certification of each commercially developed upper stage. NASA does, and will, monitor a commercial development when it is to the mutual benefit of NASA and the developer. For example, NASA monitors the PAM and TOS programs, offering advice, making recommendations, etc., but does not direct the design, thus the developer retains the responsibility for his own decisions while benefiting from NASA experience. NASA monitors stages like PAM and TOS to assess technical adequacy but does not carry the process to the point of formally certifing flightworthiness for any particular mission.

An example of a commercial development, in which NASA has had no monitoring or overview involvement, is the SYNCOM IV stage offered by Hughes Aircraft Company.

Advanced Technology Program

There is a great deal of interest in shuttle flight experiments which support NASA's advanced technology progrma such as the Space Station and other planned earth-orbit missions.

Question 37: What achievements have been made with regard to the Orbiter Experiments (OEX) program? Are we fully utilizing the available shuttle orbiter capability as a test bed to gain insight into design improvements for planned future vehicles and space structures? What specific experiments are providing data to update our space technology base?

Answer 37: The OEX program began its final research activities on the first flgiht of Columbia and Challenger. Excellent research quality data has been obtained in the areas of vehicle aerodynamics, entry heating, and thermal protection system performance.

Several notable achievements have been made under the OEX program. One example is the catalytic surface effects experiment, which validated the concept of a noncatalytic thermal protection system and the payoff of substantially lower convective heating rates for noncatalytic surfaces. This data provides the basis for development of advanced, lighter weight, heat shield designs and/or expansion of the entry flight envelope.

A second achievement, based on data from an OEX accelerometer packaged called the High Resolution Accelerometer Package (HIRAP) was the measurement of the rarified-flow transition L/D of a winged re-entry vehicle. These flight data are unique--currently unobtainable either in ground-based experiments or through computational methods. They provide the basis for a significant correction to the current empirical bridging formula used to predict the aerodynamic behavior in the transition regime. It is expected that as future flight data are folded into the ongoing analyses, a data base on rarified-flow aerodynamics will be developed, providing critical information needed for the design of vehicles operating in this high altitude regime.

Beginning in FY 1986, three key OEX instruments are to become operational on Columbia. These instruments, the Shuttle Entry Air Data Systems (SEADS), the Shuttle Upper Atmosphere Mass Spectrometer (SUMS), and the Shuttle Leeside Temperature Sensor (SILTS) will provide unique and currently unavailable data on the characteristics of the atmospheric entry environment through whcih the Shuttle flied, and on the aerodynamic flow fields and heating of the upper surfaces of the orbiter. This data will greatly enhance our understanding of Shuttle flight characteristics, enable the development and validation of leeside flow field codes and test methods, and provide essential knowledge to aid in the development of future space-entry vehicles.

The value of using the Shuttle as a research test bed is recognized by NASA and our advanced space transportation technology program is striving to fully utilize the Shuttle as a valuable national researach asset. With the addition of SILTS, SEADS, and SUMS to Columbia, plus the availability of the extensive other OEX flight instrumentation previously flown on Columbia, a well instrumented vehicle is readily available. To capitalize on this investment, we plan to extend the Shuttle performance envelope. The resultant data would greatly expand our technical base and result in a significant increase in entry vehicle capability.

Question 38: What is the status of the Orbital Acceleration Research Experiment (JOARE) to be performed as part of the OEX program? What is the relationship of the OARE progrm to the Advanced Orbiter Vehicle (AOV)? What is NASA's schedule for developing this experiment to obtain orbital atmospheric drag effect on future vehicles and large space structures?

Answer 38: The Orbital Acceleration Research Experiment (OARE) is being initiated in FY 1985 and will proceed on a schedule for a 1988 first flight.

The OARE results will be used to refine the existing experimental data base at orbital altitudes and validate the confidence in current drag prediction techniques for design of future large space structures.

The primary benefit of this program is the accurate prediction of orbital drag of large space structures such as the Space Station, and the design and sizing of orbital makeup systems required to maintain orbital altitude.

Senator GORTON. We are adjourned.

[Whereupon, at 11:07 a.m., the subcommittee was adjourned, subject to the call of the Chair.]

NASA AUTHORIZATION FOR FISCAL YEAR 1986

WEDNESDAY, MARCH 27, 1985

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:16 a.m. in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to this hearing of the Subcommittee on Science, Technology, and Space as we examine several facets of the burgeoning arena of commercial space activity.

Until recently, most U.S. space activity, with the notable exception of communications satellites, was within the domain of the Federal Government. Now, however, it is apparent that there is an expanding role for the private sector in several aspects of space activity. As promising as the future may be for commercial space development, however, we are becoming increasingly aware of the growing pains associated with defining the role of the private sector.

It is obvious that this role will not be defined overnight. Space commercialization is in its formative stage, and we must be prepared to cope with the uncertainties associated with each new step on this uncharted course.

Today we will hear from the Office of Commercial Space Transportation of the Department of Transportation relative to its activities of promoting, regulating, and serving the U.S. expendable launch vehicle industry.

In addition, NASA's Office of Commercial Programs will testify on its progress to date in implementing NASA's commercial use of space policy. This testimony will also afford us the opportunity to discuss NASA's progress in developing working relationships with industry to encourage early space ventures and to demonstrate the use of space technology to meet the needs of the marketplace.

Finally, we will focus on the issue of establishing a shuttle pricing policy for commercial users for fiscal years 1989 through 1991. This is an issue which has been complicated by different Government policies that seemingly conflict with each other. Through various policies, the Government has promoted the space shuttle as the Nation's primary launch vehicle, while also encouraging the commercialization of expendable launch vehicles.

Clearly, the shuttle pricing policy is the pivotal issue in this conflict. The significance of this issue is highlighted in the Congressional Budget Office report on shuttle pricing, which states: "No single price for shuttle services can meet all of the nation's space objectives." If in fact this is true, the final decision may adversely affect certain commercialization efforts. The various participants in this debate each have a lot at stake in this decision, and the future of our Nation's space program likewise will be profoundly affected.

Throughout the examination of this issue, the various participants have thoroughly debated the salient points, including international competition, competition between the Government and the private sector, and the future of the activities such as space manufacturing. Foremost in this discussion, however, is the need to focus on a single goal that will establish what is best for our space program and for our nation as a whole.

As we examine these issues today, we are fortunate to have several distinguished guests who will share their views. Our first witness will be Ms. Jennifer Dorn, Director of the Office of Commercial Space Transportation, who will testify on the activities of that office, after we have given Senator Rockefeller a chance for an opening statement. Senator?

Senator ROCKEFELLER. I have no opening statement, but Senator Hollings has one that he asked to have included in the record.

[The statement follows:]

OPENING STATEMENT BY SENATOR HOLLINGS

Mr. Chairman, we have finally turned the corner and have entered the Commercial Era of Space. Proof of this new Era rests with today's distinguished list of witnesses, witnesses from both the public and private sector, who are engaged in a variety of commercial space activities.

Mr. Chairman, less than one year ago the Office of Commercial Space Transportation in DOT had no enabling legislation, and the Office of Commercial Programs in NASA was but a concept. Today both are realities, as is the newly formed partnership between the Federal Government and the private sector that is working to encourage and facilitate space commercialization.

However, as is so often the case with nascent industries—all is not well. In some cases, expectations exceed realities. In others, barriers still exist that threaten commercial viability. Government policies still need to be clarified, and the Federal role needs to be more clearly defined. The old way of doing business in both sectors has to be reassessed and the political rhetoric needs to be replaced by predictable, sustained government policies.

In the course of the last year, this Committee was able to legislatively assist the early stages of space commercialization and to more clearly define the ground rules. The Commercial Space Launch Act, the Land Remote-Sensing Commercialization Act, and the FY 1985 NASA Authorization all sent a signal to industry that the government is indeed committed to space commercialization. Combined with the support of the Great Communicator and his National Policy on the Commerical Use of Space, you would think the commercial space sector has clear sailing ahead. Unfortunately, that is not the case. As we will discover during today's hearing, despite the positive first steps taken last year, there is still much that needs to be done and many policies that need to be clarified. I only hope that as a result of today's hearing, this Committee walks away better informed as to the best course of action to equip our Nation to exploit space for the benefit of the United States and the world.

Mr. Chairman, last year the Committee's NASA Authorization Report devoted a great deal of attention to space commercialization and the challenges that lie ahead. Interestingly enough, one of the key findings of the Committee was that: "Unless the public and private sector join to develop the opportunities presented by new space technologies and unless entrepreneurial forces are engaged more fully, the

United States will fall behind in the contest for leadership in space and the economic rewards associated with that position."

I am concerned, therefore, when I am advised that disharmony already exists in this nascent industry and that government policies appear to be incompatible because both threaten the newly formed partnership. The public and private sector must join together if the benefits of space are to be obtained, and I hope that today's hearing will spend some time discussing what additional steps are required to firm up this partnership.

Mr. Chairman, at the same time, I think it is quite clear that there are differences of opinion among today's witnesses as to the best shuttle pricing policy for the post-1988 period. However, as I noted above, I hope our witnesses don't let their differences overshadow their common goals and areas of mutual interest. True, interagency disputes and ~~do or die stories~~ generate a lot of newsprint, but they do little, unfortunately, to offer practical solutions to difficult problems. Hopefully, during the course of today's hearing, our witnesses will direct as much of their energy to a discussion of potential remedies to the shuttle pricing dilemma as they will to the discussion of their differences of opinion.

Finally, let me say that I am pleased the Committee is able to release its second report on space commercialization issues today in conjunction with this hearing. Entitled "Insurance and the Commercialization of Space," this Committee Print is a follow-up to the Committee's report, "Policy and Legal Issues Involved in the Commercialization of Space." I might note this report was prepared by Jane Gravelle, David Whiteman, and Marcia Smith of the Congressional Research Service. The Committee is grateful to them for this timely report which clarifies another area of importance to the commercialization of space—space insuance.

Senator GORTON. Ms. Dorn, we welcome you here and will be happy to hear your statement. I note we have many witnesses today, and we will include your entire written statement in the record. We would appreciate your summarizing it for us now.

STATEMENT OF JENNIFER L. DORN, DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION, DEPARTMENT OF TRANSPORTATION

Ms. DORN. Fine, Mr. Chairman. I am happy to do that. I am extremely pleased to be here to report to the committee on the progress of the Office of Commercial Space Transportation since the passage of the Commercial Space Launch Act a few months ago.

We feel that it was an extremely well-crafted piece of legislation and it really has assisted us in helping to remove some of the regulatory barriers which were previously confronting the emergence of a private sector launch industry.

I thought it would be useful to just briefly summarize some of our activities and accomplishments over the past several months in order for you to better understand the scope of our activities and the priorities we place on them. I think perhaps the most significant aspect of our work over the past several months has been that we have been able, through the assistance of the Executive order as well as the statute, to define and to greatly streamline the process by which companies can obtain a launch license.

On February 25, we issued a licensing policy statement which gives the kind of guidance I think the industry and all other interested parties would need in order to consider or in fact to make an application for a launch license. We plan, as a follow-on to that activity, because that indeed is the umbrella kind of concept that gives the guidance on an interim basis, to follow on with regulations respectful to third party liability insurance and commercial ranges and the development of the criteria on which we make decisions with regard to commercial ranges.

Although this policy statement is not in final form in terms of the regulatory structure that we expect in the near future, we feel we are ready and adequately prepared and willing to handle applications as they come forward. I think an adequate demonstration of the expeditiousness with which we have been allowed to handle the process because of the streamlining effect of the legislation is our mission approval, which I will discuss briefly in a moment, of the first use of space by a private launch operator.

While that portion of the license application was not the official license issuance, it represents a significant portion of the consideration that will be required of the Government and it required an extensive amount of coordination. We did that in approximately 40 days. We have also assisted companies in interactions with other agencies that are related to that policy process related to commercial space launch operations.

One issue we have been very involved in that is not directly our responsibility, but of course is very important to the industry, has been in the area of technology transfer. I know that you are very familiar, Mr. Chairman, with the ramifications of technology transfer in a broader governmental sense, and we have worked with the State Department, which is responsible for the issuance of export licenses for marketing type of data.

In this instance it was Space Services, Inc., which sought to market its vehicle overseas and thus required an export—or they thought they would require an export license. It was determined that the nature of the data they had submitted did not, in fact, require such a license to do so, but it took a number of weeks in order for us to resolve that. We are eagerly working with the State Department to try to expedite this process as well.

Another related area concerns third party liability. As you are aware, the NASA agreement with General Dynamics has two outstanding issues which we feel are very close to resolution, one of them being the level at which we will establish third party liability insurance. The level will be dealt with in a separate regulatory statement and we do not feel in any way this hampers the process of the Atlas/Centaur in marketing its goods.

In terms of the hold harmless and indemnification of the Government, we believe we have reached a very compatible, reasonable, and traditional method by which that level will be established with the Department of Transportation and the Department of Justice. NASA has agreed to that approach and we are set to move forward with regard to the privatization agreement.

With respect to range use issues, as you know, both the bill and the Executive order asked that we encourage the industry to use existing national facilities. We have done so and I think, as a result of the cooperation of those officials on the range from NASA and the Air Force, we have been able to encourage the use of those ranges by the private sector. SSI is currently considering both Wallops Island, a NASA facility, and Vandenberg Air Force Base for the launching of its projected mission.

We believe that we have been able to establish a very good working relationship and a communication network. As you know, there are differences and transitional problems, of which you spoke. Any time you have the Government doing something on other than a contracting basis, there are going to be differences in mind set, et cetera.

We have had the utmost of cooperation with officials at both the Air Force and NASA in order to accommodate commercial users on existing facilities. We think that is a good thing because we are using the Government resources—pardon me—the Government facilities that are available and the Government does not seek to use, in a very compatible fashion.

With respect to other economic policies that determine the future of industries like ours, we have been an active participant with other agencies in developing a national space policy and other types of priorities. We have been involved in the formulation of a national space strategy and have been involved in several studies on international competitiveness in the launch market.

We have been active participants as consultants or, pardon me, in the consultations with ESA on the section 301 complaint filed by the Transpase Carriers, Inc. We have also initiated a number of outside efforts in order to develop a better sense of the market and the cost of satellites, et cetera.

We remain committed to continuing the progress that we have already made in those and other fronts and are working closely with the committee to assure that we are effectively and expeditiously implementing the provisions of the law. We certainly appreciate the interest of the committee, because it has been obvious, both in the development of the legislation, they sought to get the advice of both the Department and the industry, and we see that cooperation as ongoing. We think that is extremely important to set the tone for positive interaction with the Government.

Senator GORTON. Thank you.

As you are well aware, the Air Force recently announced the decision to refurbish some of its Titan II ICBM's to launch in the 1990's some DOD and NOAA payloads. It also evidently is going to develop a complementary ELV capability. What do you see as the impact of these additional launch capabilities on a domestic ELV industry?

Ms. DORN. It is my clear understanding, Mr. Chairman, that with respect to the Titan II Program, which is a refurbishment only program, the Government has no intent of making those vehicles available to the commercial sector. They are simply meeting the defense requirements of payloads that are of a Government rather than commercial nature.

With respect to their complementary ELV Program, that again is a DOD-defined mission which would be exclusive to meeting the needs of assured access to space.

Senator GORTON. Do you believe it ought to stay that way?

Ms. DORN. Yes, sir. That is not discounting the fact, however, that the production line for the CELV that has been chosen will remain open as in accord with the Government's new policies. Depending on the economic policies of this Government, Martin Marietta, which is the contracting group, may well decide to take a derivative of that vehicle in terms of the production line capabilities and may choose to go out into the commercial market, but certainly not with that vehicle itself but with a Titan derivative. At this point it is far too large to service the commercial market. There is no question, however that the Government would not be involved in commercial payloads.

Senator GORTON. Now that the Department's advisory committee on commercial space transportation has concluded its second meeting, what recommendations have resulted?

Ms. DORN. What recommendations have what, sir?

Senator GORTON. Have resulted from the advisory committee.

Ms. DORN. I would be happy to submit for the record a comprehensive list. But the committee has been extremely cooperative in supporting our efforts and has talked a great deal about the safety aspects, the requirements of safety. With respect to the mission review, as an example, they feel very strongly, in accord with the legislation, that the Government should not be charged with assuring the success of a particular mission, but rather assuring that the system is safe for the public, a decisive recommendation on the safety orientation with which we agree.

Generally, the economic policies, in which they talk about the complementary nature of the expendable launch vehicle industry, that a fair market is important in order to establish an industry, that a market for expendable launch vehicles cannot be accommodated without that, are generally reflective of the Department's approach and I think of what we have been able to implement with respect to regulations as well.

I will be happy to submit for the record a more complete analysis as well on the status of those recommendations.

Senator GORTON. Please do. Thank you.

[The material referred to follows:]

RECOMMENDATIONS FROM SECOND MEETING OF COMMERCIAL SPACE TRANSPORTATION ADVISORY COMMITTEE, MARCH 25 AND 26, 1985

1. *Licensing process for commercial space launch activities.*—Recognizing that each member of the Committee can submit comments on the "Notice of Policy and Request for Comments" on the "Licensing Policy for Commercial Space Launch Activities", the Committee as a whole supports the thrust and direction of the policy and recommends that it be adopted by DOT.

2. *Export licensing.*—To ensure that the commercial space transportation industry is able to reach potential foreign markets and thereby help the U.S. maintain its commercial space leadership, DOT should work with the Department of State to develop a process that expedites the issuance of export licenses for technical data in support of marketing and sales of commercial launch services while satisfying national security requirements.

3. *Import duties.*—The Committee recommends that the Office of Commercial Space Transportation seek to amend existing legislation exempting from import duty all materials certified by DOT to be launched into space, spare parts, and necessary and uniquely associated support equipment for use in connection with a launch into space.

4. *Insurance.*—The Committee recommends that the Office of Commercial Space Transportation determine whether current insurance and indemnification provisions applicable to U.S. Government launches of commercial payloads should be made applicable to U.S. private commercial launches; and if it so determines, the office should take appropriate action.

5. *Proprietary data.*—The Committee is concerned with the manner in which financial, commercial, technical and other proprietary data furnished for the purpose of Government review of license applications will be handled by DOT and other reviewing agencies, and the extent to which confidentiality will be maintained. The Committeee recommends that the Office of Commercial Space Transportation (OCST), in the light of existing Departmental procedures covering the provision and

retention of such data, develop appropriate guidelines responsive to the Committee's concern. The Committee requests that the DOT advise the committee of its conclusions at the next meeting.

Senator **Gorton**. There are apparently at the present time three launch firms marketing their services: Space Services, Transspace Carriers, and General Dynamics. Do you expect that there will be more competition in that field, and can more competition be absorbed? Will it be helpful?

Ms. **Dorn**. I think, Mr. Chairman, that greatly depends on the market and what the projections are. It greatly depends on the economic policies of this Government, whether or not we will allow the private sector to compete for those services which it can offer.

We hope that through the vigorous efforts of NASA in terms of encouraging new business ventures in space, that that will give not only opportunities for new commercial ventures to come about, but the kind of visibility of programs in space that can only help other industries get interested and involved in space.

So it really varies in terms of the opportunities, what the market is, and what class of payload a certain industry wishes to serve. We hope to see an increase in that.

Senator **Gorton**. How about foreign competition?

Ms. **Dorn**. I think again much of that depends on the market itself. I think it depends on the economic policies of this Government.

Senator **Gorton**. Does it really, or are the other countries more likely to get into the business, even though there is not a market for it, simply for prestige purposes?

Ms. **Dorn**. Some of that may be true. Whether or not they will be interested or able to capture a portion of the commercial market is the question. There are a number of countries out there who are developing the technology. The interest in the commercial market is there.

They are waiting to see whether a domestic ELV industry is going to take off, because clearly the domestic ELV industry has an advantage. They have the reliability, the proven capability, and they have been involved for a number of years. That, I think, will be one of the tests.

A number of the other countries who are interested have some problems that are outside of those issues, like technology transfer is an issue for the system which the Chinese are seeking to develop. So it is very difficult to give an across-the-board statement.

It is a very dynamic environment, and I think many countries will be looking to what is happening with respect to Arianespace and domestic ELVs to determine their entry into the commercial aspect of the market.

Senator **Gorton**. You have been candid about the fact that you cannot meet the regulations regarding operations of private launch sites within 180 days. When do you expect to comply?

Ms. **Dorn**. Mr. Chairman, we think we have complied with the spirit of the law in issuing the policy statements giving the guidance necessary. As I mentioned early on, we anticipate that we will be fleshing out the policy statement in terms of specific regulations in the summer and in the fall with respect to insurance and licensing, respectively.

The issue of commercial ranges is something that we are spending a great deal of time on. However, we do not see it as immediate and there are a number of issues we really need to examine: How much should we design the criteria and the requirements for a commercial range like those that are on the national range? That will take a time longer than the 180 days.

However, we feel the policy statement really gives the guidance that is necessary to respond to any application which we may receive. Now, I will be happy to keep the committee informed of our progress with respect to specific regulations.

Senator GORTON. Ms. Dorn, I have a number of additional questions and you will be before us later for questioning. I will submit others.

Senator ROCKEFELLER. I yield my time to you, Mr. Chairman.

Senator GORTON. Thank you. In addition, some of the minority do wish to submit questions in writing and they will do so, and I hope you will respond to them as well.

[The statement follows:]

STATEMENT OF JENNIFER L. DORN, DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION, DEPARTMENT OF TRANSPORTATION

I want to thank the Chairman and members of the Subcommittee for this opportunity to appear before you today to report on the progress of the Department of Transportation in streamlining Federal regulation of commercial space transportation in ways which promote, encourage and facilitate launch activities by the private sector.

Mr. Chairman, one of the factors that has made our job at the Office of Commercial Space Transportation much easier is the careful attention Congress has paid to this issue and the clear direction it has given to our efforts. Working to develop licensing procedures and other appropriate regulations to implement intent the of the Commercial Space Launch Act provisions has served only to increase our appreciation for the very real achievement of this Subcommittee and its staff, in cooperation with the House Committee on Science and Technology. Despite the unusually brief time available to develop the bill, the Subcommittee can take justifiable pride in having fashioned a regulatory structure that both protects legitimate interests of the United States and at the same time is responsive to the industry's needs.

In the four months that have passed since enactment of this legislation we have witnessed a number of developments in commercial spaced transportation that indicate confidence in the commercial launch industry and in its potential. I doubt that anyone can predict with certainty either the nature of the contribution that private commercial launch firms will eventually make to America's space effort or the amount of time that will pass before the extent of that contribution becomes fully apparent. Nonetheless, the determined commitment of private launch firms to establish themselves in the exciting field of space commercialization provides testimony to the fact that commercial ELVs can play an important role in providing this Nation with access to space.

As part of my report to you this morning, I would like to focus on how the Department of Transportation is acting to fulfill Congress' intent, as embodied in the 1984 Act and our progress in meeting the objectives that have been set in this regard.

INDUSTRY DEVELOPMENTS

Despite the regulatory obstacles recognized by the President and this Committee at the outset and the relatively short period of time since the ELV commercialization effort started in earnest, private launch firms have already begun to make some significant gains. US ELV firms have been making serious and sustained efforts to promote their products and services in domestic and international markets. Transpace Carriers, Inc. (TCI), and General Dynamics have been marketing their launch services to potential launch customers around the world. SSI, one of the smaller and newer entrants to the industry, has been successful in attracting customers whose payloads requirements are typically smaller than those serviced by existing ELVs and the Shuttle.

INTERAGENCY ACTIVITIES

The Office of Commercial Space Transportation has participated in various policy making forums, both as a member of the Senior Interagency Group on Space, chaired by the National Security Council, and the Cabinet Council on Commerce and Trade. Its role has been to contribute to the establishment of a space strategy and to evaluate initiatives that promote and encourage private sector participation in commercial space endeavors, approved by the President on July 17, 1984. In addition, we have worked successfully with other executive agencies to establish a pricing policy for the commercial use of national range facilities and services. The direct cost pricing policy that has been adopted by the Department of Defense implements the intent of the National Security Decision Directive to promote the use of national ranges and sets charges for such use at a level comparable to that assessed government users. We are also working with the Departments of State and Commerce, the U.S. Trade Representative, and NASA to develop policies to increase the competitiveness of U.S. commercial ELVs on the world market.

ADVISORY COMMITTEE ON COMMERCIAL SPACE TRANSPORTATION

Mr. Chairman, I am also pleased to be able to report, that Secretary Dole convened the first meeting of the Department's advisory Committee on Commercial Space Transportation in October of last year. We feel especially fortunate that industry leaders in all phases of private commercialization of space have agreed to contribute their time and expertise to assist the Department's efforts to adopt policies that will encourage the growth and development of this industry. The committee's membership has been designed to include representatives from both large and small, new and established launch firms. Members have also been drawn from the investment banking, insurance, and satellite industries, and from public groups with an interest in space commercialization.

We believe that the advisory committee's expertise and insights will provide an invaluable complement to the work of our own staff in the Office of Commercial Space Transportation. The committee will hold its second meeting March 25-26 to discuss the launch licensing process and pricing issues.

REGULATORY PROGRAM

Much of our activity during the past four months has been directed to developing regulatory procedures to implement the licensing requirements specified in the Act. Among the purposes Congress articulated in the Act was the directive to DOT, as lead agency within the Executive Branch, to:

Oversee and coordinate the conduct of commercial launch operations;

Issue and transfer commercial launch licenses authorizing these activities; and

Protect public safety and the national security and foreign policy interests of the United States.

Our initial efforts to comply with this mandate are concentrated upon giving the industry a clear indication of the Federal Government's primary interests and concerns in the area of private commercial space transportation—that is, the specific regulations agencies will apply to commercial space launches—as well as an explanation of when and how those interests will be asserted. To this end, we have concentrated on areas in which current and potential industry activities are most numerous or significant and where the need for clear procedural guidance is most clearly evident. These areas involve expeditious consideration of launch license applications and specification by DOT of minimum liability insurance requirements for space launches.

The Office of Commercial Space Transportation is now in the process of issuing specific regulatory guidance in each of these areas. On February 25, we published a Notice of Policy explaining the application process for launch licenses and the interagency coordination process for reviewing license applications. The Notice also indicates the nature and timing of further regulatory guidance the Office will be issuing. A copy of the Notice is attached to the testimony I have submitted.

Because of the Subcommittee's interest, I intend to briefly outline the general nature of the licensing process we have proposed. Beyond doing so, however, I think it important to describe the additional regulations the Office will shortly issue. In this way, Mr. Chairman, I can give you and the other Subcommittee members a more complete picture of the actions now under way.

LICENSING PROCESS FOR PRIVATE COMMERCIAL LAUNCHES

We have devoted a great deal of thought and effort to developing a statement of policy which addresses clearly the questions launch firms and other interested parties have concerning the policies and procedures that DOT and other Federal agencies intend to apply in authorizing and supervising private commercial launch activities.

The basis of the licensing policy we propose to adopt is Congress' injunction that commercial launch activities be conducted in a manner fully consistent with the requirements of public safety (including the safety of property), national security and foreign policy. Equally, the policy would be to impose Federal licensing and other regulatory requirements only to the extent necessary to protect those interests. Thus, the central goal of the policy is to realize these objectives within a framework which responds to this emerging industry's needs for both regulatory flexibility and certainty.

The regulatory framework we have designed to accomplish these requirements encompasses two specialized review processes: Mission Review and Launch Safety Review. These reviews may be conducted independently of each other and in the order (either sequential or concurrent) that is more appropriate to the nature of a specific launch.

Mission Review is the mechanism for considering the proposed launch activity in the context of the United States' international obligations as well as our national security and foreign policy interests. DOT is responsible for ensuring that a proposed launch activity, (including the launch of a vehicle, the placement of a payload in space or both) does not constitute a hazard to public health or safety and is not adverse to either U.S. foreign policy or national security interests. DOT has devised the mission review process as the means for addressing these factors.

In the course of a mission review, DOT and other agencies will examine the objective of the proposed launch and the means by which the launcher proposes to accomplish that objective. When we speak of "objective" we mean the reason for having a launch, such as to test a new vehicle or to place a telecommunications satellite in geostationary orbit. When we speak of the "means" for accomplishing the objective, our interest is in elements of the proposal such as the flight plan or the design of the payload. If the payload is one for which a prior Federal approval is required, for example an FCC license, our statute requires us to avoid duplicating the evaluation made of the payload by the responsible Federal Agency.

On the other hand, if the launch activity is directed toward placing a payload in space for which no prior Federal approval is required, DOT and other agencies would have to assess the proposed mission to determine whether the launch should be prevented because the launch of the payload in question would be hazardous to public health or safety or adverse to U.S. foreign policy or national security interests. The proposed launches by Space Services, Inc. of payloads containing cremated remains were reviewed in this manner before mission approval was granted.

The other component of the launch licensing process involves the *Launch Safety Review*. This inquiry addresses the range and vehicle safety resources an applicant can assembled to guarantee safe launch operations. Specifically, the review will focus on such factors as the suitability of the proposed launch site and flight path, the safety expertise of range personnel, ground and flight safety process and procedures, range tracking and instrumentation capability, vehicle safety systems (including flight termination mechanisms), and proposed vehicle design.

It should be noted that an applicant's choice of the site from which it proposes to conduct a launch can effectively reduce the number of safety issues DOT must address. If an applicant proposes, for example, to launch from an established national range, where safety requirements governing equipment, personnel qualifications and launch procedures developed by the government operator of the range are already in place, many of the launch safety requirements will be satisfied simply by a statement of intention to launch from that range. The launch license would be conditioned by the requirement that the applicant comply with all applicable safety requirements and procedures of the range. Similarly, once DOT has developed requirements and procedures for licensing private launch sites, an applicant will be able to secure prompt launch safety approval by indicating an intention to utilize such a licensed commercial site.

When a firm has obtained both mission and launch safety approval, DOT will issue a license incorporating certain necessary and appropriate conditions pertaining to the license holders' activities from the time of license issuance through the actual launch. These conditions can be expected to include requirements that the licensee adhere strictly to range safety regulations and procedures that specific safety measures be undertaken, that airspace restrictions be observed, that a specified amount of liability insurance be obtained, and that Federal inspection, verification and enforcement requirements be complied with.

LIABILITY INSURANCE

Let me turn now to the other elements of our regulatory program. We plan to issue an Advance Notice of Proposed Rulemaking concerning liability insurance issues. The Notice explains—and requests public comment on—issues we have identified in the area of liability insurance that we believe the Office will have to address in the process of setting minimum amounts of liability insurance, as required under Section 16 of the Act for specific space launches or for the operation of private launch sites.

We are especially concerned with the area of third party liability for damage caused to persons or property that are not involved with the launch or other space-related activity for which the Office issues a license. Our primary objective here is to ensure that insurance levels are set at a level sufficient to compensate third parties for damage and adequate to cover any liability the United States may incur as a result of the international obligations it has assumed under the 1972 Liability Convention.[1] At the same time, however, we want to be able to set insurance levels that will neither impose inordinate economic burdens on launch firms nor prevent firms from obtaining insurance at reasonable rates. Thus, we will be examining in this rulemaking proceeding the central question of whether DOT should undertake its own analyses of the risks associated with individual space launches or whether we should direct—as NASA has done for commercial payloads on the Shuttle—that launch firms purchase the maximum amount of insurance commercially available, or some combination thereof.

As the Subcommittee is well aware, liability insurance is only one of many issues the Office of Commercial Space Transportation must consider in the process of licensing nongovernmental space launches. Like the policy statement itself, launch licensing regulations will serve as interim guidance to applicants concerning the requirements for obtaining licenses and the procedures the Office will follow in evaluating their requests for launch approvals.

LICENSING COMMERCIAL LAUNCH SITES

The other major licensing responsibility committed to the Department involves the operation of private commercial launch sites. The issues presented here are numerous and in many ways more complex. I say this primarily because government and industry are only beginning to identify their respective interests in the operation of commercial launch sites. The Administration has demonstrated and justified its interest in encouraging commercial launch firms to utilize the excellent facilities and extensive expertise available at U.S. Government ranges. Indeed, both NASA and the Air Force are making sincere and significant efforts to assure launch operators that their commercial needs—especially their near term needs—can be met effectively on national ranges. While commercial launch firms have been receptive to using these government facilities, some have indicated that private launch sites may suit their needs as well.

My primary concern with regulation of commercial launch sites is that the Federal Government not commit itself to a rigid regulatory approach too far in advance of actual development of this segment of the industry. We believe that a more responsible approach is to explore and evaluate a variety of regulatory steps that can accommodate operational flexibility and yet ensure safe operations.

With this goal in mind, the Office of Commercial Space Transportation will initiate studies of regulatory alternatives which will support our licensing operations at private launch sites. We in cooperation with other Federal Government agencies, are considering issuing performance standards for private launch site operations and challenging the industry to develop appropriate procedues for meeting these standards. We are also paying a great deal of attention to methods for encouraging the development of launch safety expertise in the private sector. These include possible certification of launch safety inspectors as well as personnel capable of monitoring launch vehicle assembly and payload integration.

For the reasons stated both here and in the Notice of Policy attached to this statement, we do not believe that issuance of even interim regulations governing operations at private launch sites is an objective we can responsibly achieve within the 180 day period contemplated by the Act. We hope, nonetheless, to be able to publish within that period a formal document on this subject. This document will specify the issues we believe must be addressed before specific regulations can be drafted. It also will identify the regulatory alternatives we think are available to use to fulfill Congress' intent that commercial launch sites are operated responsibly.

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[1] Convention on InternationalLiability for Damage Caused by Space Objects, 24 U.S.T. 2389 (1972).

RESOURCE ISSUES

Let me turn now to the resources I believe will be required to support the work of the Office of Commercial Space Transportation. As I testified before this Subcommittee last year, the Department has made available the necessary resources to support the activities of this Office within the budget request for the Office of the Secretary.

A core staff has been assembled to carry out the provisions of the President's Executive Order and the Commercial Space Launch Act. Eleven full time permanent positions have been officially assigned to this office, with extensive participation by the staff of the General Counsel's office. In addition, two detailees from the Air Force have been assigned to the Office of Commercial Space Transportation in order to provide technical support in the areas of ELV launch operations and their regulation.

The Department is also enlisting contractor support in the areas of regulatory requirements development, research and alternatives analysis, and the competitive posture of domestic and foreign launch capabilities.

CONCLUSION

Mr. Chairman, this Committee's leadership assistance has been and will continue to be of critical importance in our efforts to implement the goals articulated in the Commercial Space Launch Act. We view the facilitation of the commercial launch industry as an important component of America's space transportation program. We look forward to your continued interest and support. I will be happy to answer any questions you may have.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. According to your testimony, the issue of third party liability insurance is still undergoing review in your office. I hope the Committee's CRS report on space insurance will shed some light on the subject.

What are some of the considerations you will take into account in determining whether DOT undertakes its own risk analysis or whether DOT requires its customers to purchase the maximum amount of insurance available?

What conclusions have you or the Advisory Committee reached on the issue of the Government providing back-up launch insurance for ventures which cannot be fully insured commercially?

How and to what extent do you believe launch insurance rates have affected or will affect a satellite owner's selection of a launch capability?

Answer. The Department recently issued an Advance Notice of Proposed Rulemaking inviting public comment on the matters surrounding third-party liability insurance for commercial space launch activities. The Office of Commercial Space Transportation staff is also proceeding with internal research and analysis activities, including discussions with the insurance industry, the user community, and other Federal agencies. In formulating a specific regulatory proposal, we will carefully consider the CRS report and any comments we receive from the public.

A major purpose of our proceeding on third-party liability insurance is to identify the considerations which bear on the choice between risk analysis and commercial availability as the alternate methods for determining the appropriate level of coverage.

The Office of Commercial Space Transportation has found that, as a general rule, insurance is available commercially to cover all risks, provided one is willing to pay a sufficiently high premium. Consequently, we are not convinced that the Federal Government could become an insurer of last resort without competing with private sector sources of insurance.

If the Federal Government steps in to provide insurance at rates the launch industry considers to be reasonable when insurance is available commercially at rates the industry finds unreasonable, then the government is, in effect, providing a subsidy. Such action would be in direct conflict with Administration policies. At the same time the Office of Commercial Space Transportation is sensitive to concerns that sufficient insurance underwriting capacity is available to support private commercial space efforts. We are monitoring the situation closely in order to determine the appropriate role for the Federal Government.

Arianespace officials have informed us that they have offered to cap insurance premiums—that is, to pay the difference between higher Arianne premiums and lower Shuttle or U.S. ELV premiums. They indicated, however, that the difference has been decreasing and that it will soon become unnecessary to cap insurance premiums.

In any event, insurance premiums have, until recently, represented a relatively small proportion of the total cost of putting satellites into orbit. This is especially true in the area of third party liability coverage, DOT's primary area of statutory concern. Since the differences in the size of the premiums if different launch firms have had to pay have not been very great up to the present, we believe that launch insurance premiums have not significantly affected a satellite owner's selection of a launch capability. If insurance premiums continue to increase, and if the differences widen, launch insurance premiums could affect such selection in the future.

Question. Ms. Dorn, Arianespace believes that it will be able to capture about one-third of the 143 civilian satellites to be launched over a five-year period. Yet over the past 14 months, Ariane has captured one-half of the ten competitions for civilian satellite launches.

How much of the future market do you think that Ariane is capable of capturing and what are the constraints on Ariane's capabilities?

To what extent will Ariane increase its prices as Shuttle prices increase, and to what extent will the Shuttle pricing policy really affect Ariane's market share?

Answer. Arianespace officials have recently informed us their goal is to capture six or seven launches per year through the end of the decade. They also plan to capture up to ten launches per year during the 1990s.

We believe that constraints on Arianespace's capabilities include production and launch infrastructure, financial restrictions, the market, customers' desires for diversification, and other space initiatives.

Additional capacity would require substantial investments in:

Production capacity at numerous supplier facilities,

Payload processing and integration capacity,

Propellant storage capacity, and

Upgrading of the existing ELA-1 launch pad at Kourou, French Guiana.

Arianespace would have considerable difficulty in orchestrating a major increase in production rates among dozens of suppliers located in 11 Western European countries. Arianespace is required to allocate contract funds in proportion to national contributions. With such a financial straitjacket, Arianespace would be hard pressed to expand production or to change direction quickly. Based on our observations of Airbus production, we believe that Arianespace could not quickly increase its production and launch capability by a significant proportion.

European Space Agency (ESA) and Arianespace officials have told us that the market is too small to justify such investments because the added return would not be sufficient. Since its establishment, Arianespace has benefitted from:

The increasing value of the dollar, inasmuch as Arianespace receives most of its revenues in dollars and pays most of its expenditures in francs, marks, pounds, and lire;

A larger number of launch orders than anticipated;

Launch delays in the case of competitors, and

Higher interest rates than anticipated.

A major change in any of these factors could further reduce the return from any such investments. Commercial customers unwilling to rely exclusively on a single launch vehicle system prefer to pay somewhat higher prices for diversification in order to be assured reliable and timely launches. These customers can obtain such assurances by booking some of their launches on the Shuttle or on one of the U.S. commercial ELVs rather than on Ariane.

During its meeting on January 30 and 31, the European Space Agency Council approved, in principle, a significant increase in ESA's budget. The increase includes funds for European participation in the space station and for development of the Ariane 5, with an advanced cryogenic engine. The Europeans would prefer to fund development of advanced technology rather than investments to support additional production and launch capability for current Ariane launch vehicles.

Arianespace officials have stated that they would raise Ariane prices by a comparable amount if the U.S. Government were to raise Shuttle prices. They maintain that Arianespace has had to shave its profit margins in order to compete with the Shuttle, and, more recently, with TCI. They indicated that Arianespace would like to raise prices in order to build up its profitability for the sake of its shareholders.

Question. Has the issue of what costs commercial ELV launch operators should pay for the use of Government (NASA or DOD) facilities been resolved? Have NASA and DOD agreed to charge only direct, or additive, costs for the use of their respective facilities?

Answer. As directed in the Commercial Space Launch Act, commercial launch vehicle operators will be charged direct cost for the use of government facilities. This policy is reflected in various policy documents issued by the Department of Defense and in interval directives currently being drafted.

NASA officials have assured us that they will take a very similar approach in implementing the direct cost policy.

Question. What role has your office had in assisting domestic ELV companies in their marketing efforts?

Answer. The role of the office has been primarily to assure the public and the financial community that the Administration is serious in wanting to encourage a private sector launch industry and that commercial companies are capable of launching satellites on their own, with our need of government assistance or participation (other than meeting licensing requirements). On several occasions, we have informally put satellite operators in contact with launch service suppliers, and vice versa. The office also has the lead in implementing of the Commercial Space Launch Act.

Question. Ms. Dorn, the CBO study suggests that a Shuttle pricing policy that reflects marginal, or additive cost recovery will result in a more efficient and effective use of the Shuttle? Do you agree, and if not, why?

Answer. The aspects for this question are currently being debated within the Administration. Several agencies, including DOT are actively involved in these discussions. The outcome of these discussions will be used to advise the President on a Shuttle pricing decision. Once the President makes his decision, we will fully brief the Committee on the elements of the Administration's Shuttle pricing policy.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS

Question. In the Senate Commerce Committee Report for the Commercial Space Launch Act, the Committee clearly indicated its "feeling" that the Office of Commercial Space Transportation warrants a separate authorization.

In light of this instruction, why has the funding for your Office been included in the Office of the Secretary account? When can the Committee expect to see this situation remedied?

Answer. The Office of Commercial Space Transportation was formed and commenced operations in January 1984, pursuant to Executive Order 12465 and under the Secretary's general authorizations contained in the DOT Act. Except for authority to issue regulations and a section related to surplus Federal launch property, none of the provisions of the Commercial Space Launch Act became effective until April 30, 1985, well after the President's FY 1986 budget was submitted to Congress as a final document. Because the Appropriations Committees have taken up the budget for action in this form, the Department does not expect to propose a revision to it.

Question. In your testimony you indicate that the Department is enlisting contractor support in the areas of regulatory requirements development, research and alternatives analysis, and the competitive posture of domestic and foreign launch capabilities.

Would you please give the Committee a more thorough description of the type of support that has been contracted for in FY 1985 and what is proposed in FY 1986? How are these activities funded? Have any outside studies been contracted for concerning shuttle pricing policy? What were the principal findings of these latter studies?

Answer. In FY 1985, the Office of Commercial Space Transportation will fund contracts in the following areas. These funds are taken from the Office's allocations for salaries and expenses and for Transportation Policy Research and Development.

An analysis of financial criteria that would be used for cost recovery if the Shuttle operated by a private sector business on the basis of generally accepted accounting principles (GAAP): Includes comparison of how interpretations for full cost recovery would be applied in government context.

Technical analysis of commercial launch site criteria and range design concepts: Identify essential elements of national range safety standards that are relevant to commercial range operation. Help establish systems capability for the Department of Transportation to conduct risk analysis of varied launch scenarios for both liquid and solid fueled launch vehicles.

Analysis of launch vehicle technologies for three families of expendable launch vehicles: Ariane, Atlas-Centaur, and the Delta. Cost, profit or subsidy estimates, and quantifiable measures of competitiveness will be examined. A rating system shall be established to compare technologies on a by-vehicle basis.

In addition, we are in the process of contracting for the following:

ENVIRONMENTAL ANALYSIS FOR LAUNCH LICENSING

Environmental analysis of commercial launches from national ranges or non-government sites. Will adopt or incorporate to the greatest extent possible environmental assessments or impact statements that currently exist for government ELV programs and ranges. Likely to be an 8(a) set-aside.

RISK ANALYSIS FOR THIRD PARTY LIABILITY

Identify basic risk analysis options available to Office of Commercial Space Transportation in establishing third party liability insurance requirements for commercial space launches.

SITING CRITERIA FOR COMMERCIAL LAUNCH SITES

Identify criteria that the Office of Commercial Space Transportation should consider in evaluating proposed launch sites, and identify analytical tools and models to assess a site's potential launch capability.

REGULATORY AND TECHNICAL CONSULTANT SERVICES

Develop safety standards in an entirely new regulatory field by tapping into the extensive operational safety experience that the government has had in managing its own range facilities.

ELASTICITY OF LAUNCH SERVICES

Investigation of the relationship between the price of launch services and the demand for launch services. Price elasticity can be divided into two parts: (1) to what extent would higher launch costs cause cancellation of planned communications satellites, and (2) to what extent would higher priced transportation inhibit the development of commercial projects or new commercial space markets. Only the first part will be contracted for this year.

UPDATE OF PAYLOAD PROJECTIONS

Contractor or subscription services by which the Office of Commercial Space Transportation can update the data base we established in FY 1984. The prospective number of satellites changes constantly with new technological development and new rulings by the FCC.

INDICATORS OF FUTURE INTERNATIONAL MARKET SHARES

Contractor services to identify future early-warning indicators of how international shares of the launch market may change.

Question. On February 25, the Department of Transportation issued the interim "Licensing Processes for Commercial Space Launch Activities." First, let me compliment your Office for doing such a commendable job of conforming this process to the legislation.

Next, let me ask why didn't your Office advise the Members of this Committee that you would have problems meeting the requirements of Section 25(c) concerning the implementation of regulations within 180 days of the date of enactment?

Answer. In response to the requirement of the Commercial Space Launch Act to issue regulations within 180 days, the Office of Commercial Space Transportation issued a Notice of Policy which operates as interim guidance to launch applicants. Because of the need to comply with a number of other statutory requirements (performing an Environmental Assessment, coordinating proposed regulations with other federal agencies, and the requirements of the Administrative Procedure Act for public comment periods, as examples), it became clear that issuance of final regulations within this timeframe would not be possible. It was concluded, however, that the Notice of Policy met the legislative intent to provide timely guidance to commercial launch vehicle operators.

Question. In your testimony, you indicated that the Department's Advisory Committee on Commercial Space Transportation met in October of last year.

Would you please submit a list of the members of this Advisory Committee? Who is the Chairperson of this Committee? What are the Advisory Committee's goals and objectives, and how was its membership constituted?

Answer. A list of the membership is attached.[1] The chairman of the committee is Gerald J. Mossinghoff, President of the Pharmaceutical Manufacturers Association, former Assistant Secretary of Commerce and Commissioner of Patents and Trademarks.

The goals of the Committee are to evaluate economic, technological and institutional developments relating to the commercialization of ELVs, to serve as a forum for the discussion of problems involving the relationship between industry activities and government requirements, and to make recommendations to the Secretary on issues and approaches for Federal policies and programs with respect to the development of private sector space transportation.

The Department sought membership which would constitute a reasonable balance between smaller entrepreneurs and larger aerospace companies, between industry representatives and public members, and what we believe to be a fair representation of all the potential concerns facing a developing industry, such as insurance, financial investment, legal considerations and satellite customers.

Questions. Pursuant to the October Advisory Committee meeting, eight recommendations were submitted to Secretary Dole to "help the nation maintain its strong commercial launch vehicle capability."

What actions have been taken to date regarding each of these recommendations? Are administrative remedies available for each of these recommendations or will legislation be required?

Why didn't the list of recommendations address Federal procurement policies and procedures?

Are all "commercial space" interests included within the framework of the DOT Advisory Committee? For example, Recommendation #1(D) references the "commercial space industry—ELV, upper stage, and spacecraft producers." Are all of these groups represented?

Answer. Several of the recommendations you refer to represent the positions of the Advisory Committee about issues which are being deliberated in interagency bodies, and we have made these views known to these bodies. Recommendations dealing with safety are being implemented promptly by being incorporated in our regulatory requirements. Some are of such a nature that no immediate action can be taken. It is too soon to know whether or not any will require legislation.

The Advisory Committee, in two meetings, has never raised Federal procurement policies and procedures as an issue. Thus far the Committee has focused primarily on launch services offered in a commercial vein, and not in response to government procurements.

It would be impractical to include all commercial space interests in the Advisory Committee. We believe however, that we have achieved a broad representation of transportation service providers (the major ELV manufacturers), as well as the leaders in the manufacture of communications satellites (Hughes Aircraft Co.) and Boeing Aerospace Co., manufacturer of the IUS upper stage.

Question. The Office of Commercial Space Transportation was established to license and regulate commercial space launch vehicles. At the same time, the Secretary was directed to encourage, facilitate and promote commercial space launches by the private sector.

Can this Office function as both an advocate for ELVs and as a regulator of ELVs without compromising itself? Should the commercialization of ELVs be considered outside the general issue of space commercialization?

Answer. We do not see a conflict between our promotional role and our regulatory role. DOT has responsibilities for both promoting and regulating other forms of transportation, such as aviation in accordance with the Federal Aviation Act of 1958, as amended and the separate roles of the Maritime Administration versus the Coast Guard.

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[1] The attachment is in the Committee file.

Providing an efficient licensing process which protects public safety is DOT's chief role and, in fact, is essential to the development of a health commercial space transportation industry. Launch companies want to see clear and reasonable regulatory guidelines before they can be certain that the government is serious about removing regulatory burdens and encouraging commercial space endeavors.

Question. The Commercial Space Launch Act directs the Secretary, or the Secretary's designee, to be an active participant in negotiations for launch property and launch services.

To what extent has your Office been involved in negotiations concerning the privatization of the Scout ELV? Will the Scout system, in your opinion, be privatized, and what is its likely market?

Answer. NASA has not yet released its solicitation for commercialization of the Scout. We were asked to review their draft of the solicitation, and have given them our comments. A number of firms have expressed interest in the Scout as a potential commerical vehicle. It is as yet unclear how much of a market the new operators can develop beyond that which the Scout is currently servicing.

Question. In the Commercial Space Launch Act, the Senate Commerce Committee did not include any provisions for the licensing of upper stages. Rather, the Committee indicated that the licensing of upper stages warranted additional study in the future.

Has your Office given this matter any additional consideration, and what recommendations, if any, would you make?

Answer. When we issue a license to launch a commercial vehicle and any payload we will address the safety issues associated with the entire launch activity: the vehicle, payload, and any upper stage involved. We believe it is appropriate that DOT's regulatory authority be confined to commercial vehicles as now provided for under the Act. NASA has sole responsibility for upper stages used by payloads carried on the Shuttle.

Question. In your testimony concerning "liability insurance," you indicate that there is a debate as to the merit of DOT undertaking its own risk analysis of space launches versus requiring the maximum amount of liability insurance.

Have you given any consideration to the establishment of a "certification process" within the FAA or NASA for upper stages and launch vehicles to reduce the insurance market's perceived technical risks?

Answer. Under the Act, DOT's responsibility is to ensure that commercial space launches are safe. In this regard, DOT was assigned responsibility to establish third party liability insurance levels. Our study of risk analysis addresses the specific question of what level of third party liability is sufficient to compensate the public for damages in the unlikely event an incident results in loss to life and/or property.

Mission success for unmanned commercial launch vehicles is the responsibility of the private sector. We do not consider "certification" of commercial launch vehicle reliability in a nonsafety context to be an appropriate role for the government. The issue of "certification" of unmanned vehicles is a first or second party insurance issue. The insurance market focuses on the underwriters' risks when it insures against the loss of a payload operators satellite and future profits. At this time, nothing is planned by DOT in this regard, although we remain open to consideration of proposals that can be accommodated by our statutory mandate and which serve to promote and encourage the industry.

Question. Your Office recently approved its first payload pursuant to your new licensing authority. How did that process work, and what have you learned about the process from that first submission and approval?

Answer. On January 2, 1985, Space Services, Inc. (SSI), requested a statement of "official position" by the Secretary, pursuant to her authority under the Commercial Space Launch Act (P.L. 98-575) as to whether she would act to prevent the launch of a class of payload SSI hope to launch which otherwise requires no Federal license, authorization or permit. Under the Act, the Secretary may prevent launch of any such payload that she determines, in consultation with other responsible Federal agencies, will jeopardize the public health and safety, safety of property, or national security of foreign policy interests of the United States.

As required by the Act, we worked with the National Aeronautics and Space Administration, and the Departments of Defense, State and the Air Force to determine whether the launch of "cremains" would jeopardize these national interests. We ascertained that SSI's spacecraft, which has a volume of less than 30 cubic feet, presented no threat of on-orbit collisions and would not affect any U.S. civil or military space projects or foreign spacecraft. We also determined that this action had no measureable effect on the space environment. Accordingly, SSI was notified that the Secretary would not act to prevent the launch of a payload of this type.

The process established to address this issue worked well. Although the "cremains" proposal represented a new type of application, DOT concluded the evaluation process within six weeks, with much cooperation by other Federal agencies. We believe the process meets government responsibilities and is responsive to the needs of industry.

Question. The Senate Report for the Commercial Space Launch Act requires the Secretary to submit a report by July 1, 1985, that identifies Federal statutes, treaties, regulations and policies which may have an adverse effect on commercial launches. Is this report being prepared, and will it be submitted by July 1?

Answer. We are working on the report and intend to provide it as soon as possible. However, extensive coordination will be required with other agencies, and we do not believe it will be ready for transmittal to Congress by July 1.

Question. Do commercial ELVs compete with the Shuttle, or do they complement the Shuttle?

Answer. U.S. ELVs and Shuttle have complementary capabilities. It is true that, for a particular segment of the market, primarily communications and remote sensing satellites (Shuttle's and ELVs compete for the same market). It is important to note that this segment represents a very small portion of the Shuttle's total business, since its main business is comprised of DOD, civil government and research and development missions.

Question. Do commercial EVLs compete with Ariane? Can commercial ELVs compete with government-supported systems?

Answer. Commercial ELVs offer similar technology to that used by Ariane—unmatched reliability, and the flexibility to be responsive to customer needs that only private-sector operations can offer. We believe they can thus be better competitors than the Shuttle in many ways.

Question. Does Ariane compete with the Shuttle? If the U.S. is to maintain its world leadership position in providing commercial space transportation, don't Shuttle prices have to be competitive with Ariane?

Answer. Ariane competes very effectively with the Shuttle. 50 to 70 percent of the commercial market has gone to this expendable alternative to the STS during the past year. It is anticipated that Arianespace will keep its bids at whatever price will allow them to fill capacity. The present Shuttle price of $71 million has not deterred its marketing efforts. Arianespace has indicated that it would like to increase its price to put it on a more business-like basis, but has also stated it must subsidize Ariane in order to match Shuttle subsidized prices.

We believe the prospects for U.S. leadership in commercial space transportation will be greatly enhanced with U.S. commercial ELVs exerting their own strong competitive presence around the world. The Shuttle's role in maintaining U.S. leadership in space transportation will not be assessed on the number of commercial and foreign satellites launched, but rather on its many other outstanding and unique capabilities. Manual tending of manufacturing processes in space or retrieval and return of errant satellites, construction and service of a space station and other capabilities can only be offered by a manned system like the Shuttle. Expanding these capabilities and their use is a true opportunity for American leadership in space.

Question. Is Ariane heavily subsidized, or did they operate in the "black" in 1984? Doesn't Ariane benefit from inherent cost advantages as well as an historically strong dollar? Does the Ariane pricing policy reflect full cost recovery?

Answer. While Arianespace claimed a small profit in 1984, its profit and loss statement does not reflect a number of significant costs, including research and development range, ESA and French Government personnel costs. Moreover, the small net profit that has been claimed by Arianespace actually reflects an operating loss of their launch vehicle activities that is more than offset by a financial profit from:

Income on investments of Arianespace's initial capitalization, and

The Arianespace float—the difference between its front-loaded progress payments from customers to Arianespace and its back-loaded contract payments from Arianespace to suppliers.

Ariane has been benefiting greatly from the very favorable exchange rates. It would require only a relatively small shift from current high dollar values to more traditional/historical exchange rates, however, to make Ariane costs equivalent to a much higher shuttle price.

Ariane asserts its prices do reflect full cost recovery, but certain costs, as noted, are not included.

Question. Is it important for this nation to have an ELV backup capability to complement the Shuttle? If so, why? If not, why? Do the recent Air Force decisions to develop a complementary expendable launch vehicle [CELV] and to refurbish Titan IIs give the U.S. such an ELV capability?

Answer. We believe it is very important to have a complementary U.S. ELV capability. Communications satellite operators have stated their preference for ELVs, which is supported by the strong showing of Ariane in capturing 50-70% of the commercial market.

U.S. ELVs are the best hedge against uncertainties in Shuttle capacity as well as an important addition to our competitive presence in the International marketplace.

DOD believes it is important to maintain our ELV industrial base to have assured access to space. CELVs will contribute toward fulfilling both of these objectives, but a robust commercial ELV industry will ensure that a long-term industrial base that is not totally reliant on government contracts is in place to act as a buffer against the uncertainties of launch supply and demand.

It is the intention of the Department of Defense to refurbish a limited number of Titan IIs to accommodate a particular class of payload for DOD. Commercial launches will not be offered. These vehicles do little to maintain the industrial base since new vehicles will not be manufactured, only a limited number refurbished and made available for government use.

Question. Should the federal government take steps to guarantee the survival of the domestic ELV capability such as preclude the launch of communications satellites by the Shuttle? Would such a step actually guarantee the economic viability of commercial ELVs? Wouldn't such a policy have an adverse effect on NASA's budget?

Answer. It would be difficult to implement a policy which would guarantee the economic success of any system, not is it DOT's desire to do so. If, when competing with U.S. ELVs, the Shuttle loses some payloads, there will be minimal effect on the NASA budget. This effect however, can be countered by a positive effect on the U.S. budget through taxes, and increased employment in a U.S. ELV industry. Shuttle pricing based on overly optimistic assumptions can have a more negative effect on total appropriations for the Shuttle program, if projections continue to be unmet and costs continue to be higher than prices charged.

Question. Do commercial ELVs affect total launch demand, or do they merely affect the market shares of the Shuttle and Ariane? Is this true over the long term as well as the short term?

Answer. Certainly, competition from U.S. ELVs will affect Shuttle and Ariane market share. U.S. ELVs use the same technology as that of Ariane and can offer non-price incentives similar to those offered by Ariane. By being available to accommodate those payloads that don't require a manned vehicle (only a small share of the total market), additional capacity can be available for new, unanticipated uses of the Shuttle.

Although market share may be affected, it is important to remember that the most effective way to bring launch costs down is through competition. In the long term, free market competition would lower launch costs and stimulate demand. This will not happen if subsidized Shuttle and Ariane prices preclude entry of private sector launch providers.

Question. In you opinion, what is the most appropriate Shuttle pricing policy for the 1989-91 time frame? What goals are associated with that policy? What would be the cost of a full orbiter payload bay under your preferred pricing policy? And at that price would the Shuttle remain competitive with Ariane?

Answer. The aspects of this question are currently being debated within the Administration. Several agencies, including DOT are actively involved in these discussions. The outcome of these discussions will be used to advise the President on a Shuttle pricing decision. Once the President makes his decision, we will fully brief the Committee on the elements of the Administration's Shuttle pricing policy.

Question. Based on your analysis, what is the projected demand for commerical communications satellite launches for the next five years? For the next ten years? What is the existing launch capability for this same period of time? Isn't it true that for the short term, launch capability far exceeds demand?

Answer. The aspects of this question are currently being debated within the Administration. Several agencies, including DOT are actively involved in these discussions. The outcome of these discussions will be used to advise the President on a Shuttle pricing decision. Once the President makes his decision, we will fully brief the Committee on the elements of the Administration's Shuttle pricing policy.

Question. Based on your *analysis,* at what level would Shuttle prices need to be set to permit commercial ELVs to *compete* with the Shuttle for commercial communications payloads in the 1989-91 time period? Would this shuttle price level ensure the commercial ELVs ability to compete with Ariane?

Answer. We believe that a full cost recovery Shuttle pricing structure similar to that originally established by NASA for the Shuttle program will ensure a fair and free market in which U.S. ELVs can compete.

Question. Besides Ariane, are any other foreign nations interested in *developing* and *marketing* launch capabilities? What is the expected time frame for these foreign systems to come on line? Isn't it likely that these systems will receive government support?

Answer. A number of other nations, such as the Soviet Union, Japan, and China, are developing or have developed their own systems and are interested in marketing launch capabilities. All of these systems are expected to receive government support. However, we believe there will be major obstacles to their obtaining a significant portion of the commercial market for the next ten years.

Question. Do you accept NASA's position that fixed-costs represent *two-thirds* of the total operational costs of the Shuttle if at least eight flights are flown? And that the fixed-costs are the same for a flight rate of 8-24 flights per year?

Answer. NASA has a very detailed cost base which supports these numbers. We have not reviewed them in detail.

Question. What is your estimate of marginal launch costs for 1989-91 time frame? How did you compute that number? What is the current marginal launch cost?

Answer. We have not made an independent estimate. NASA's estimates that marginal cost would be $33 million for that time period. We do not have an estimate for the current marginal cost.

Question. What does the term "full cost recovery" mean to each of you? And what elements would you include in this term? What elements are included in the government's ELV full cost recovery pricing policy? Should "full cost recovery" be the principal policy objective of the Shuttle program?

Answer. The aspects of this question are currently being debated within the Administration. Several agencies, including DOT are actively involved in these discussions. The outcome of these discussions will be used to advise the President on a Shuttle pricing decision. Once the President makes his decision, we will fully brief the Committee on the elements of the Administration's Shuttle pricing policy.

Question. Is the Shuttle an "operational" system or is it still in the research and development stage? Should the same pricing policy criteria apply to a "R&D" activity as to an "operational" system?

Answer. NASA has stated that the Shuttle is not yet an operational system. It is expected to become operational on October 1, 1988. Until that time, recognizing that it is an R&D activity, the Shuttle will be priced on a basis that does not recover its cost.

Question. Does the maturing nature of the Shuttle program and its previous learning experiences increase the probability that future cost estimates will be more accurate? That future launch rate estimates will be more accurate?

As the Shuttle gets closer to operational status, the accuracy of future cost estimates and launch rates should improve.

Question. What influence do economic assumptions have on Shuttle pricing policy options? Does Shuttle pricing policy have any budgetary consequences?

Answer. Assumptions as to demand (i.e., the number of communications satellites requiring launch services, the growth of materials processing in space applications, and future government requirements for the Strategic Defense Initiative and the Space Station) and supply (i.e., Shuttle capacity, the competitive price of Ariane as influenced by exchange rates, and the availability of commercial ELV entrants at different Shuttle prices) have great significance as to the viability of various pricing options.

The outcome of the Shuttle pricing policy debate may have significant budgetary implications, particularly if Shuttle capacity fails to develop as projected. If government and foreign and commercial demand expands (as we expect it will) the U.S. government may be faced with difficult choices between maintaining market share or deferring government payloads. Additional Shuttle capacity will come at significant expense—in excess of $2 billion.

Question. Should Shuttle pricing policy be based on projected Shuttle flight rates or projected Shuttle operational capability? In light of the National Research Council's "Assessment of Constraints on Space Shuttle Launch Rates" is the assumed flight rate of 24 flights per year in 1989 realistic for planning or pricing purposes?

Answer. The aspects of this question are currently being debated within the Administration. Several agencies, including DOT are actively involved in these discussions. The outcome of these discussions will be used to advise the President on a Shuttle pricing decision. Once the President makes his decision, we will fully brief the Committee on the elements of the Administration's Shuttle pricing policy.

Question. Is it realistic to assume that the operating cost per flight will decrease from approximately $137 million/flight in 1984 to $39 million/flight in 1989? What are the principal factors accounting for these substantial economic gains?

Answer. We must defer explanation of the factors accounting for these gains to NASA.

Question. During the Executive Branch Shuttle pricing debate, are any steps being considered, related to pricing policy, that would make the space Shuttle more attractive to the commerical sector?

Answer. The focus for what measures can be taken to make the Shuttle more attractive to the commercial sector lies in NASA's commercialization program. A major focus of NASA's efforts is to encourage the development of new commercial ventures which require the unique capabilities of the Shuttle. It is well recognized that one action which would make the Shuttle more attractive to the commercial sector is to establish long run price stability.

Question. Are the expectations of profit by the private sector in space realistic? Or is a well-known space executive correct when he says that private sector investment in space is "over-exposed," "over-advertised," and fraught with "too much hype?"

Answer. All agencies within the Administration are working to create an environment where new commercial ventures in space can flourish. This will require a transition from what has been a contractor orientation to one where free market forces bring about increased stimulus for new space applications.

As on earth, one necessary ingredient will be a flexibile and robust transportation infrastructure, where the powers of private sector competition will be forcing costs down, and making more potential projects economically viable.

Senator GORTON. If you will wait around to be a part of the panel, we will hear from Isaac Gillam, Assistant Administrator for Commercial Programs at NASA.

STATEMENT OF ISAAC T. GILLAM IV, ASSISTANT ADMINISTRATOR FOR COMMERCIAL PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Senator GORTON. Mr. Gillam, in your case as well your entire written statement which we have received will be included in the record, and we will appreciate a summary of it at this point.

Mr. GILLAM. Thank you, Mr. Chairman.

Mr. Chairman, I welcome this opportunity to testify on the fiscal year 1986 budget request of NASA's Office of Commercial Programs. Our funding request for $30 million will support the research and development initiative contained in the administration's national commercial space policy and implement NASA's Commercial Use of Space Program. Our funding request for $11.1 million will continue the NASA Technology Utilization Program.

Our office is moving expeditiously to involve the private sector to the greatest extent possible in the exploitation of space through the effective utilization of the available tools, such as the space transportation system and other existing NASA capabilities, as well as future capabilities such as the space station.

NASA's fiscal year 1986 commercial programs budget has been developed to encourage the commercial use of space in two broad areas: as I have mentioned earlier, the commercial development and technology utilization. I will be describing the 1986 budget request for the TU Program later in my testimony. We, at NASA, view the TU Program and our commercial development efforts as complementary.

I will describe some of the commercial program initiatives for which funding has been requested in fiscal year 1986. We believe that through a partnership of industry, Government, and universities, NASA Centers for the Commercial Development of Space will help stimulate the basic research that will provide the fundamental knowledge needed to form the basis of new commercial space ventures.

While the Government will provide some funding to stimulate the development of these high technology basic research ventures, an investment of resources on the part of the private sector is necessary for the Centers to become self-sustaining within 5 years.

NASA plans to fund three to six centers for the commercial development of space at a rate of $500,000 to $1 million per center, beginning this fiscal year. We are primarily interested in research in electronic materials, metallic alloys, glasses and ceramics, biological materials, and fluid dynamics.

NASA recently established an Advisory Council Task Force for the Commercial Use of Space, chaired by Dr. Thomas A. Vanderslice. It is comprised of executives representing nonaerospace companies. The Vanderslice committee is taking a close look at the possibilities for the nonaerospace industry to participate in NASA-sponsored research. The use of advisory panels, with an emphasis on nonaerospace participation, is we believe an effective mechanism for providing private sector inputs into NASA's research agenda.

Perhaps the greatest barrier to undertaking a commercial space venture is the large capital costs associated with doing the basic and applied research. The greatest driver of these capital costs is the development and acquisition of facilities and equipment. NASA is seeking to enable industry and university researchers to consider space flight experimentation without prohibitive major investments in highly specialized equipment by making available facilities and equipment in the same manner that the NASA aeronautics facilities have been made available in the past to industry.

NASA hopes to stimulate potential private sector commercial space research through a combination of Government funding and private resources. With a focus on the commercial potential of materials processing, especially within the nonaerospace community, this initiative is intended to stimulate entrepreneurial and university involvement in space research with the greatest potential, while increasing the number of scientists and engineers involved in these research activities.

As with any other commercial space proposal NASA receives from the private sector, two key evaluation criteria will be applied: the degree of risk being assumed by the private sector and the potential benefits that will accrue to the Space Program and the Nation.

NASA's Administrator, Mr. James Beggs, has directed the Commercial Program Office to fund only those projects which can demonstrate a commitment of resources on the part of the private sector. As such, the Commercial Development Division in reviewing commercial space projects submitted by NASA field centers will seek the maximum leverage of Federal funds with private resources.

Over the last 25 years, NASA has developed a unique working relationship with the aerospace community. In an effort to do the same with companies outside the aerospace community, we will begin an outreach program to establish a dialog with universities and those potential private sector clients to gain an understanding of their key problems and to mutually determine how space research and technology can be of assistance.

The outreach program will cut across both commercial development and technology utilization functions within the Office of Commercial Programs. As important as it is to reach out to universities and the private sector to stimulate commercial space research, it is equally important to establish a dialog with those companies who may benefit from existing applications with NASA-developed technology, represented by our Technology Utilization Program.

NASA's technology utilization program funding request is $11.1 million in fiscal 1986. The TU Program, with its focus on the dissemination and application of technology derived from NASA research, will continue its previous role with expanded responsibilities in the commercial use of space and space technology.

The Technology Utilization Program is designed to stimulate wide-scale transfer and secondary use of aerospace-derived technologies throughout the Nation's economy. We believe that the many beneficial uses resulting from NASA's technology transfer efforts in the past have been significant and fully justify the continued emphasis which the Congress and NASA have placed on this important activity.

Over the past 2 years, NASA has been moving steadily forward in improving its information dissemination systems. As reported to this committee last year, system improvement in support of NASA's industrial applications center network, including remote interactive search systems, high-speed computer search capabilities, and expanded use of electronic mail as a delivery mechanism are continuing to be enhanced.

Through our fiscal 1986 budget request, NASA will strengthen technology transfer and dissemination methods employed by the NASA Industrial Application Centers.

A primary focus of NASA's efforts to encourage commercial use of space is on new high-technology ventures that create new wealth, new technology and increased economic activity. A key NASA barometer of private sector interest in these new technology ventures is the number of proposed agreements submitted by companies. Mechanisms such as joint endeavor agreements, have been used by NASA as a way to facilitate the demonstration of commercial applications in space technology through a NASA-industry partnership. Under a joint endeavor agreement there is no exchange of funds between NASA and the private sector. Rather, a quid pro quo is established whereby, in exchange for a flight or flights aboard the space shuttle and/or other services, a private company will structure the experiment, build the hardware, package the experiment, and share with NASA the experimental results.

The Office of Commercial Programs has been established as an agency-wide focal point for the commercial use of space. NASA field centers have also established points of contact to expedite review and maintenance of commercial agreements. Every step will be taken by NASA to avoid stifling private sector innovation and creativity by an overly cumbersome approach to proposal evaluation.

Recent experience does suggest that when NASA and a private company work cooperatively to establish a commercial space agreement, the NASA system is indeed very responsive. The 3M Corp. and NASA entered into a memorandum of agreement covering a joint space-based materials research program in February 1984. 3M's diffusive mixing of organic solutions experiments flew on shuttle mission 51A less than 9 months after the original agreement was signed.

For the next few minutes I would like to briefly describe some ongoing NASA activities and mechanisms that are also contributing to the goal of expanding the level of private sector investment in space. For example, the Small Business and Innovative Research Program represents an ongoing NASA program that can be particularly useful in increasing the number of companies pursuing commercial space ventures. Using the procedures and practices of the SBIR Program, the Office of Commercial Programs hopes to stimulate the involvement of small businesses in space research activities.

NASA has also been proceeding with the necessary steps to transfer the Delta, Atlas/Centaur, and Scout expendable launch vehicles, the ELV's, to the private sector in accordance with national policy and the recently enacted Commercial Space Launch Act. The Office of Commercial Programs will serve as the focal point for providing support to the Department of Transportation in carrying out its lead agency responsibilities and for commercial ventures associated with elements of the space transportation system.

The success of NASA's efforts to stimulate private sector involvement in space activities is critically dependent on the quality of the working relationship between the Office of Commercial Programs and other NASA program offices. A close working relationship has been established with each program office to avoid duplication of effort and to ensure the smooth integration of our activities.

For example, our office and the Space Station Office are both new offices which share the goal of developing a permanently manned space station that both stimulates and supports commercial endeavors in space. Our relationship with the space station office is a positive one. The space station program places heavy emphasis on mission or payload requirements and we can be assured, I believe, of the program having a small commercial dimension.

The Office of Commercial Programs stands ready to assist the private sector in the pursuit of commercial space endeavors. Some of the major challenges NASA will face in carrying out this mission involve the development of an adequate microgravity research data base, reaching out to the nonaerospace entrepreneurs, and assuring affordable access to space.

Mr. Chairman, the support of this committee in focusing on commercial space issues has been appreciated and we look forward to building on this established relationship in the future.

This completes my prepared statement. I will be pleased to answer questions at this time.

Senator GORTON. First, I would like you to speak to the subcommittee about the centers for commercial development of space. How many proposals have you received? How do you judge them? How are you going to assure they become self-sustaining? And most particularly, what is going to happen to that program if in fact Congress votes for a freeze on the NASA budget rather than the level recommended by the administration?

Mr. GILLAM. I will try to start at the top, Mr. Chairman.

The Centers for Commercial Development of space is a continuation of an existing program with a commercial focus. Such activities have been operated within the Government for several years. As you know, the NASA Microgravity Sciences Program in the Office of Space Sciences initiated the start of two centers last year. They have in previous years also done the same.

There is a slight bit of difference in our centers. What we are using is the same procedures and selection criteria as has been used in the past by the Office of Microgravity Sciences. A primary difference is that our research activity will focus on those areas of microgravity science that have what we, and hopefully the private sector, believe have near-term potential private sector applications, as opposed to a general research and science effort, as the microgravity program does. That is the major difference between our efforts.

Other than that, the centers will be quite similar. It is clearly NASA's intention, as I stated in my opening statement, that private sector funds be involved in this effort from the beginning. I said "funds"; that is a mistake. Private sector resources; it could be either manpower or funds.

We believe that such an investment is necessary in order to demonstrate a real interest on the part of the private sector in what we are doing. Our plans are that at the end of five years NASA will cease funding the center, whether it is self-sustaining or not. But at the beginning we will try to review the proposal to make an evaluation of whether or not that their becoming self-sustaining is something that will truly happen. We intend to use the standard selection criteria. We intend to use the process of peer review. We intend to use the existing NASA processes in making those selections.

I am not sure that that answered all of your questions.

Senator GORTON. What happens if NASA is subject to a freeze?

Mr. GILLAM. If we are subject to a freeze, we will have to reduce the number of centers. As you know, we have an $8.5 million level budget for fiscal 1985 and if we are frozen to the $8.5 million level we will not be capable of having as many activities as we had planned in our 1986 budget request.

Senator GORTON. I understand that Mr. Beggs said that if NASA overall is subject to a freeze at least the implication is, that he would transfer some money out of the commercial programs into other higher priority areas. Am I incorrect in that respect?

Mr. GILLAM. My impression of what Mr. Beggs said is, if we are frozen at our 1985 levels, he would look at continuing this program at its 1985 level, which is $8.5 million, as opposed to the request for $30 million.

Senator GORTON. What is the status of NASA's negotiations with Space Shuttle of America Corp. with respect to that company's interest in buying or leasing one or more orbiters?

Mr. GILLAM. We are in the process of evaluating a third proposal that has been provided to us by Shuttle America. We have evaluated two proposals against criteria that I believe we submitted for the record a couple of years ago when we were evaluating our first proposal for the request for a fifth orbiter by the Space Transportation Co. of New Jersey.

We are still using those criteria in conducting our evaluation of proposals. We do not really talk about the specifics of the proposals while we are in negotiation, but we have been in discussions for approximately 3 weeks on the third variation of their proposal.

Senator GORTON. In any event, this is something which is of interest to NASA?

Mr. GILLAM. Yes, it is.

Senator GORTON. On another similar proposal, a local publication states that NASA has received an unsolicited proposal to develop a NASA-Commerce lab, a family of facilities for commercial and scientific users that would be available initially on the shuttle and later on the space station.

What is the status and the initial attitude of NASA towards this proposal, and what is the so-called family of facilities?

Mr. GILLAM. The Commerce Lab proposal is a proposal that results from a study initiated by the Office of Space Sciences and Applications on the use of the spacelab facilities, tools and equipment for commercial purposes, for U.S. domestic commercial purposes.

As you know, several spacelab missions have been purchased, there have been two spacelab missions purchased by the Europeans, the Germans, and one portion of a spacelab mission has been purchased by the Japanese. Our office, working with the Office of Space Science and Applications, looked at how we might be able to try to put together a spacelab mission composed exclusively of U.S. domestic private sector experiments, and that I believe is what that article was reporting.

Senator GORTON. What success has your office had in attracting potential customers who are specifically interested in the space station?

Mr. GILLAM. We have been working mostly with the Space Station Office in doing that. The way we perceive our role is that we are sort of precursors in terms of research and experimental work for customers who eventually would expect to use the space station. Since a substantial portion of our efforts are associated with microgravity sciences, we believe that the space station will be doing a substantial amount of either research or manufacturing work resulting from the experimentation that we are initiating on the Shuttle or a further continuation of experimentation.

So, we see ourselves as the office that establishes initial contact with the private sector, gains an understanding of their interests and what they would like to do in space, gains an understanding of their problems and how space might solve some of those problems, and performs initial work with the private sector on the space shuttle which will eventually lead to work on the space station. So, we perceive it as a kind of hand-off process, but initially they will work with us and the other NASA program offices, and downstream a bit we all will pass them on to station. At the same time, we will be giving inputs to the station organization with respect to their requirements, but later on we will pass the customers on to the station as potential users of the station.

Senator GORTON. Senator Rockefeller, any questions?

Senator ROCKEFELLER. No.

Senator GORTON. I have a substantial number of additional questions which we will submit to you for written response, as will the minority. For now, we thank you. I trust you will stay with us while we hear from Dr. Eric Hanushek of the CBO.

Mr. GILLAM. Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF ISSAC T. GILLAM, IV, ASSISTANT ADMINISTRATOR, OFFICE OF COMMERCIAL PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Distinguished Members of the Subcommittee:

We welcome this opportunity to testify on the Fiscal Year 1986 budget request of NASA's Office of Commercial Programs. Our funding request for $30.0 million will support the research and development initiative contained in the Administration's National Commercial Space Policy and implement NASA's Commercial Use of Space program. Our funding request for $11.1 million will continue the Technology Utilization Program, which was formerly managed by NASA's Office of External Relations.

As this is our first opportunity to testify since the establishment of the Office of Commercial Programs, my remarks will focus primarily on those activities which are being initiated in FY 1985 in accordance with our letter to the Congress in December and our planned approach to encouraging the commercial use of space.

The creation of the Commercial Programs Office and issuance of NASA's Commercial Use of Space Policy have demonstrated NASA's continuing commitment to opening the frontier of space to private enterprise. The Office of Commercial Programs is moving expeditiously to involve the private sector, to the greatest extent possible, in the exploitation of space and its resources through the effective utilization of the available tools, e.g., the Space Transportation System and other existing NASA capabilities, as well as future capabilities such as the Space Station.

NASA's FY 1986 Commercial Programs budget has been developed to encourage the commercial use of space in two broad areas: Commercial Development and Technology Utilization. Many of you are familiar with the Technology Utilization (T.U.) Program, but may not be aware that the T.U. Program is now being administered by the Commercial Programs Office.

The FY 1986 funding request of NASA's Office of Commercial Programs will build upon the commercial use of space activities initiated in FY 1985. In seeking a greater private sector commitment of resources to commercial space research and development, NASA's FY 1986 commercial program's budget request will support the commercial development of space in the following areas:

Centers for the Commercial Development of Space:

The objective of NASA's Centers for the Commercial Development of Space (CCDS) is to stimulate high technology research directed to the development of projects in space which have commercial potential or will contribute to possible commercial ventures. Through the CCDS process, NASA anticipates that government facilities and flight opportunities will be made available through Joint Endeavor or Technical Exchange Agreements. One method for facilitating the movement of technology from the laboratory to the marketplace has been demonstrated through a partnership of industry, Government, and universities in the establishment and operation of joint research centers. The NASA Centers for the Commercial Development of Space will help to stimulate the basic research that will provide the fundamental knowledge which will form the basis for new commercial ventures in space. In these Centers, the private sector will play a critical role in defining the R&D agenda that will have the best potential for commercial payoffs.

The Government will provide some funding to reduce the private sector financial risks for these high technology basic research ventures, but an investment of resources on the part of the private sector is also required. The Centers for the Commercial Development of Space must become self-sustaining within five years.

NASA plans to fund three to six Centers for the Commercial Development of Space at a rate of $500,000 to $1 million per Center per year beginning in FY 1985. We recently invited industry and universities to respond to a Center for the Commercial Development of Space Notice of Opportunity. Based on our current plans, we expect to receive these proposals by June 1985, and award funding by early September 1985. A review panel comprised of representatives from industry, universities, and government agencies will evaluate the technical and business merits of proposals. Potential research areas that have been discussed include: electronic materials, metallic alloys, glasses and ceramics, biological materials, and fluid dynamics.

Stimulating NASA Research with Commercial Potential:

The growing awareness, stimulated by the Space Shuttle, of the unique attributes of space as a research environment has created the opportunity for greater industry involvement in space R&D activities. Through greater industry involvement in setting NASA's space research agenda, we can aggressively seek and conduct research directly aimed at enhancing commercial space endeavors.

NASA's Advisory Council Task Force for the Commercial Use of Space, chaired by Dr. Thomas A. Vanderslice, is comprised of successful executives representing non-aerospace companies and is taking a very close look at the possibilities for non-aerospace industry participation in NASA-sponsored research. The use of advisory panels, particularly those with an emphasis on non-aerospace participation, will have a significant input in setting NASA's research agenda.

In FY 1986, NASA will conduct research with potential commercial applications in several technology areas including: low-g solidification of superalloys, low density material production, biotechnology, microgravity research, and communications.

Increasing the Availability of NASA Facilities:

Perhaps the greatest barrier to undertaking a commercial space venture is the large capital costs associated with doing the basic and applied research. The greatest "driver" of these capital costs is the use and acquisition of facilities and equipment. NASA is seeking to enable industry and university researchers to consider space flight experimentation without major investments in highly specialized equipment by making available Government facilities and equipment in the same manner that the NASA aeronautics facilities are available to industry.

In FY 1986, NASA has also requested funding to expand the availability of facilities such as furnaces, optical fiber production devices, and automated protein crystal growth devices. These facilities will be made more readily available to researchers examining commercial space technologies.

Stimulate Private Sector Commercial Research:

NASA can help stimulate potential private sector commercial space research through a combination of government funding and private resources. With a focus on the non-aerospace community, this initiative will stimulate entrepreneurial and university involvement in commercial space research, while increasing the number of scientists and engineers involved in these research activities.

NASA funding of private sector commercial space research will help to reduce the up-front risks and costs of basic research that will support commercial space endeavors. The procedures of NASA's Small Business Innovation Research Program represent one approach that will be used to stimulate private sector commercial research.

As with any other commercial space proposal NASA receives from the private sector, two key evaluative criteria will be applied: the degree of risk being assumed by the private sector, and the potential benefits that will accrue to the space program and the nation. NASA's role in evaluating these proposals is not to determine "winner" or "loser" commercial space ventures, but rather to stimulate private sector involvement in commercial space endeavors.

Outreach:

Over the last 25 years, NASA has developed a unique infrastructure and working relationship with the aerospace community. In an effort to forge a similar relationship between NASA and companies outside the aerospace community, an outreach program will be conducted to establish a dialogue with universities and those aerospace and non-aerospace companies most likely to pursue commercial space ventures. In addition to establishing a dialogue, this activity will enhance NASA's links with industry, universities, and the financial and insurance communities.

Some examples of outreach initiatives that will be funded in FY 1986 include researcher exchange programs with industry and universities, technical liaison with major industrial sectors, finance and insurance community seminars, and technical information dissemination.

The outreach program will cut across both the Commercial Development and Technology Utilization functions within the Office of Commercial Programs. As important as it is to reach out to universities and aerospace and non-aerospace companies to stimulate commercial space research, it is equally important to establish a dialogue with those companies who may become interested in marketplace applications of existing NASA-developed technology. At NASA we view the Technology Utilization Program and our commercial development efforts as complementary.

Technology Utilization Program:

In FY 1986, NASA's Technology Utilization Program funding request is $11.1 million.

The Technology Utilization (T.U.) program, with its focus on dissemination and application throughout U.S. industry of technology derived from NASA research, will assume a vital role in assuring the synergism needed to encourage the commercial use of space.

The Technology Utilization Program is designed to stimulate wide-scale transfer and secondary use of aerospace-derived technologies throughout the nation's economy. We believe that the many beneficial uses resulting from NASA's technology utilization efforts in the past have been significant and fully justify the continued emphasis which NASA has been placed on this important activity.

Through our FY 1986 budget request, NASA will strengthen technology transfer and dissemination methods employed by the NASA Industrial Applications Centers. NASA dissemination center network outreach initiatives are also being strengthened by further developing productive relationships with state governments and state-operated institutions serving the technological and economic needs of their industries. These efforts are fully consistent with report recommendations made by the President's Commission on Industrial Competitiveness.

During the past year, the T.U. Applications Engineering Program has made significant strides in its effort to modify and adapt or re-engineer existing aerospace technologies to match significant technological problems of national scope. During FY 1984, nearly $6 million in non-NASA support from industry and other Government agencies aided in these jointly-sponsored programs. It is anticipated that during FY 1985, this support may reach the $15 million level.

Commercial Agreements:

The focus of NASA's efforts to encourage the commercial use of space is on new high technology ventures that create new technology, and new economic activity. One of the key NASA barometers of private sector interest in these new high technology ventures is the number of existing and proposed agreements submitted by private companies. Mechanisms such as Joint Endeavor Agreements have been used by NASA as a way to facilitate the demonstration of commercial applications in space technology through a NASA-industry partnership. Under a Joint Endeavor Agreement there is no exchange of funds between NASA and the private sector. Rather, a "quid pro quo" is established whereby in exchange for a flight or flights aboard the Space Shuttle and/or other services, the private company furnishes NASA with flight results, such as data or materials as well as structuring the experiment, building the hardware, and packaging the experiment at its own expense.

NASA has executed Technical Exchange Agreements (TEA's) with four U.S. corporations. These TEA's provide for the use of NASA ground-based facilities and aircraft to support private sector low-g research interests. Areas of investigation include alloy solidification, crystal growth, deposition of thin films, and catalytic research.

In addition, NASA has signed six Joint Endeavor Agreements (JEA's), three of which support basic research activities and three which support the development of in-space service hardware. Companies pursuing research under a JEA include McDonnell Douglas/Ortho Pharmaceutical Company, 3M Corporation, and Microgravity Research Associates. The three research JEA's involve, respectively, processing of biological materials of pharmaceutical interest, basic research into organic crystals and thin films, and production of electronic crystals.

A number of proposed JEA's are currently in the review and evaluation process. These JEA candidates involve basic research activities, development of experimental hardware (e.g., furnaces) to support space-based research, and development of in-space services hardware ranging from Get Away Special sized apparatus to manned-habitable modules.

Other Commercial Programs:

For the next few minutes, I would like to briefly describe some ongoing NASA activities and mechanisms that are also contributing to the goal of expanding the level of private investment in space.

The Small Business Innovation Research (SBIR) Program represents an ongoing NASA program that can be particularly useful in increasing the number of companies pursuing commercial space ventures. Using the procedures and practices of the SBIR Program, the Office of Commercial Programs hopes to stimulate the involvement of small businesses in space research activities.

In both FY 1985 and FY 1986, NASA will be taking steps to include small businesses in its efforts to pursue commercial space research. Potential research areas for small business involvement include: electronic materials, metallic alloys, glasses and ceramics, biological materials, fluid dynamics, chemistry and physics, life sciences and space technology.

NASA has also been proceeding with the necessary steps to transfer operation of the Delta, Atlas/Centaur, and Scout expendable launch vehicles (ELV's) to the private sector in accordance with National policy and the recently enacted "Commercial Space Launch Act." The Office of Commercial Programs will serve as the NASA focal point for providing support to the Department of Transportation in carrying out its lead agency responsibilities, and for commercial ventures associated with elements of the Space Transportation System.

A formal agreement between NASA and Transpace Carriers Incorporated (TCI) for the transfer of marketing and production responsibilities for the Delta launch vehicle was signed last year. Negotiations with General Dynamics, who has expressed interest in becoming the commercial operator of the Atlas/Centaur Program, are still in process. Inquiries have also been received for the Scout vehicle, but the selection process for a private sector operator has not been completed.

There are currently two existing egreements between NASA and private firms for development of commercial upper stages: one with McDonnell Douglas for the Payload Assist Module (PAM) and one with Orbital Sciences Corporation for the Transfer Orbit Stage (TOS). Several other private companies have made investments in other upper stages, although no agreements with NASA exist at this time. Although some of these upper stage ventures can utilize ELV's, others cannot and therefore their commercial success is highly dependent on the Space Shuttle. Even those that can fly on ELV's have the majority of their investment in support equipment which is Shuttle-unique.

There are two other major agreements which NASA has entered into with private firms for the provision of space flight hardware and services. The first is a Joint Endeavor Agreement with Fairchild Space Company for Leasecraft and a Memorandum of Understanding with Astrotech International Corporation for payload processing services.

Relationships with Other NASA Offices:

The success of NASA's efforts to stimulate commercial involvement in space activities is critically dependent on the quality of the working relationship between the Office of Commercial Programs and NASA's other program offices. A close working relationship has been established with each program office to avoid duplication of effort and to insure the smooth integration of activities. For example, many of the commercial research activities being proposed require on-orbit time in zero-gravity; therefore, the Office of Commercial Programs must work closely with NASA's Office of Space Science and Applications, and the Office of Space Flight (Customer Services Divisions) to achieve the desired results.

Another instance is where our office and the Space Station Office are both new offices which share the goal of developing a permanently manned Space Station that both stimulates and supports commercial endeavors in space. Our relationship with the Space Station Office is a positive one. We have worked with their Utilization and Requirements Division to supply the Space Station mission data base with over thirty new commercially oriented candidate missions. This data forms the basis of the performance envelope that is shaping the Space Station system requirements and includes, as one of three categories, commercial missions.

Key Challenges in Encouraging the Commercial Use of Space:

The Office of Commercial Programs stands ready to assist aerospace and non-aerospace companies in their pursuit of commercial space endeavors. Some of the major challenges NASA will face in carrying out this mission involve developing an adequate microgravity research data base, reaching out to the non-aerospace entrepreneurs, and assuring affordable access to the Space Shuttle.

Mr. Chairman, the support of this Committee in focusing on commercial space issues has been appreciated and we look forward to building on this established relationship in the future.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Backup for Shuttle

Question 1: Mr. Gillam, it has been reported by the media that NASA is considering use of the Delta launch vehicle as a backup for some Space Shuttle missions. This backup would be provided to alleviate the congestion brought about by Shuttle mission cancellations.

This leads to the following questions:

a. Could you comment on the benefits of having the capability to offload payloads when some launches have last minute troubles and must be delayed?

b. What benefits would accrue to the government and to NASA if we had a strong backup capability, and to what extent would these new launches of Delta accelerate the transition of Delta to the private sector?

Answer 1: There are obvious benefits of having the capability to offload payloads to alternative systems. Studies have thus far indicated these benefits can be overshadowed by the costs. These costs come from two sources: the additional costs of maintaining alternative systems and the costs of "dual compatible payloads." It is primarily for these reasons that the United States has not provided for such a capability in its first quarter century in space.

Specific benefits to the civil space program for such a capability would depend on the available flight rate capacity and schedule flexibility of a primary Government system. A backup would provide extra launch capability and, perhaps, increase schedule confidence that would have to be traded off against the cost of maintaining the system and the impact on payloads with dual compatibility.

CBO Study

Question 2: Mr. Gillam, according to the CBO study, NASA's proposed policy of $87 million "remains substantially less than the price implied by the original pricing policy to cover all operating and production costs." Could you respond to this statement in the CBO study?

Answer 2: The statement means that there were certain principles contained in the original pricing policy that were not included in the formulation of the original NASA proposal which resulted in the $87 million price. Specifically, it does not include charges for the use or depreciation of Government capital assets or a premium for reflight insurance in the original policy. Nevertheless, the $87 million price is responsive to the requirements of the Presidential directive to recover the full cost of foreign and commercial Shuttle operations.

Ariane Impact

Question 3: Mr. Gillam, you believe that Arianespace will be able to capture about one-third of the 143 civilian satellites to be launched over a five-year period. Yet, over the past 14 months Ariane has captured one-half of the ten competitions for civilian satellite launches.

How much of the future market do you think that Ariane is capable of capturing and what are the constraints on Ariane's capabilities?

Answer 3: The question contains an assertion concerning my beliefs that is inaccurate. Ariane has stated that its goal was to capture one-third of the market. I believe that was their original goal before realism established that there would not be 143 satellites available for launch over the next five years. Most recent studies indicate that there may be less than 100 satellites available. One-third of 143 is slightly less than 50 satellites or slightly less than 10 per year (approximately five equivalent launches). One-third of 100 is approximately 33 satellites or slightly less than 6 per year (approximately three equivalent launches). To the three equivalent launches, add two ESA launches and one arrives at a very inefficient production and launch rate -5. Under these circumstances, they will need a greater percentage of the market to utilize their existing capabilities efficiently.

In our opinion, Ariane is capable of capturing nearly 70 percent of this reduced market without increasing its existing capability and, with a modest investment of less than $50.0 million, is capable of greater percentages of the market. The future market that Ariane will be able to capture is largely dependent on STS prices, their technical reliability, and demand.

Question 4: To what extent will Ariane increase its prices as Shuttle prices increase, and, to what extent will the Shuttle pricing policy really affect Ariane's market share?

Answer 4: We assume that Ariane will follow one of two pricing strategies: price to market or price to cost. Therefore, we believe that Ariane will raise its prices to the extent that they are currently pricing below cost with an appropriate element of profit. In any event, we believe that they will consistently price below Shuttle or other competitive systems. Shuttle is the only factor in Ariane pricing where Shuttle is the only competition.

Commercial ELV Industry

Question 5: Mr. Gillam, the CBO study suggests that a Shuttle pricing policy that reflects full cost recovery will adversely affect a domestic ELV industry, and likely, end its existence. What are the implications of the United States having no commercial ELV industry?

Answer 5: If the United States were to have no commercial ELV capabilility, we would have to rely on the Shuttle and any government ELV capability. An ELV capability to complement the Shuttle currently exists and is projected to exist for the foreseeable future. NASA's use of Expendable Launch Vehicles will extend through 1987, or later, in some instances, in support of reimbursable customers who had made earlier commitments to be launched by an ELV system. The Air Force decision to use surplus Titan II military missiles for space application will extend ELV capabilities into the 1990 period. In addition, the Air Force decision to develop a Complementary Expendable Launch Vehicle (CELV) also will extend our ELV capability. The Shuttle is this Nation's primary Space Transportation System, and a U.S. ELV capability will exist for a number of years, but primarily to meet DOD needs not commercial needs regardless of the domestic ELV industry.

Multi-Tiered Pricing Policy

Question 7: Could you comment on the merits or faults of incorporating, in a pricing policy, a royalty fee that is based on the income generated from activities such as space manufacturing that require Shuttle launch services?

Answer 7: This is a concept worthy of consideration. It could reduce the risk to investors and potentially result in larger long-term returns to the Government. The Government's receiving a royalty from space ventures when using Shuttle was explored in the past. In its favor is the ability to recover direct fees in support of Government space operations, thereby, lowering the NASA appropriation. If NASA is already recovering the full cost of providing Shuttle services, this fee or royalty would represent a profit to the Government which may require the enactment of new legislation. However, before adopting such a policy we would like to discuss it with the Administration and potential customers as part of a market research activity.

Marginal Cost Pricing

Question 8: Mr. Gillam, the CBO study suggests that with a short-run marginal cost pricing policy, the Shuttle will operate more efficiently, and effectively, but that this pricing policy will adversely affect a domestic ELV industry.

What is NASA's projection for the Shuttle's marginal costs in the FY 1989-1991 period?

Answer 8: NASA's estimate for Shuttle marginal costs for the FY 1989-1991 period is approximately $33 million in 1982 dollars based on 24 flights per year.

Question 9: In arriving at this number, how many annual flights have you assumed, and how are marginal costs affected by the flight rate?

Answer 9: Our projections are based on the target of 24 flights per year as directed by the President. Within a range of one to four, in the variability of the flight rate, the marginal cost is relatively stable. With larger numbers, the additive cost would increase.

Joint Endeavor Agreements

Question 10: According to your testimony, NASA has signed six Joint Endeavor Agreements (JEA's), three of which support basic research activities, and three of which support the development of in-space service hardware. How many other JEA's of these two types do you expect to sign, in the foreseeable future?

Answer 10: The execution of a Joint Endeavor Agreement depends upon the extent of interest shown by both the private sector and, on the other side, the Government. The depth of private sector interest in any one area cannot be predicted and the result is that the number of agreements cannot be forecast.

NASA currently has, under various stages of review, about two dozen proposals, about one-third of which are potential JEA's.

Question 11: What areas of activity or research will these JEA's address?

Answer 11: The substantial majority of proposed agreements deals with materials processing in space. Most of the remainder deals with space hardware of various types. A very few involve information exchange of one type or another.

Microgravity Experiments

Question 12: Why have NASA's own microgravity experiments had so much difficulty in being manifested aboard the Shuttle?

Answer 12: Many of the NASA microgravity experiments are mid-deck experiments and as such are manifested as secondary payloads to optimize the Shuttle load factor after the primary payloads requirements have been met. In addition several of the missions have been C.G. constrained such as the STS 51-A mission in November 1984 which precluded the full utilization of the mid-deck for experiments. This was due to the late requirement to retrieve the two communication experiments which also necessitated the postponement of the Materials Experiment Assembly (MEA) which is now scheduled for an October 1985 launch. The MEA has been previously flown on Shuttle in June 1983. In addition, there have been five flights of the Monodisperse Latex Reactor, five flights of the Continous Flow Electrophoresis System (CFES) and one flight each of the Acoustic Containerless Experiment System, the Isoelectric Focusing Experiment, the Aggregation of Red Blood Cells, and the Diffusive Mixing of Organic Solutions--all microgravity experiments.

Question 13: What is being done to increase the Shuttle flight opportunities for NASA's microgravity research programs?

Answer 13: NASA is very interested in increasing the Shuttle flight opportunities for their microgravity research programs and has scheduled several payloads on upcoming flights. In June of this year, NASA plans to fly the Automatic Directional Solidification Furnace. The Materials Science Laboratory is scheduled for launches in August and December of this year and will be flown approximately every three months after the planetary missions next May. Also on the August 1985 flight, the Inertial Blood Storage Experiment, the Continuous Flow Electropheresis System and the Physical Vapor Transport of Organic Solids are scheduled. The mid-deck assignments after August have not been scheduled pending final major payload manifesting requirements; however, it is expected that several other NASA microgravity experiments will be scheduled. As the Shuttle flight rate increases the opportunities for scheduling more of this type of payload will increase.

Private Sector Use of NASA Facilities

Question 14: I commend your office for attempting to increase the availability of NASA's facilities to industry and university researchers who otherwise would be unable to afford the large equipment investment. Just how are you making this option known to the industrial and academic communities?

Answer 14: The Office of Commercial Programs is currently planning an Outreach Program that will establish the institutional mechanisms needed to stimulate a strong partnership between business, universities, and NASA. It is through such an Outreach Program that the opportunities for industry and university researchers to use NASA facilities and equipment will be communicated. NASA is currently examining alternative outreach mechanisms. Examples of outreach initiatives for which funding is proposed in FY 1986 include researcher exchange programs with industry and universities, technical liaison with major industrial sectors, and technical information dissemination.

Question 15: What costs are associated with these two communities using NASA's facilities?

Answer 15: As part of the Administration's support of basic research, NASA attempts, wherever possible, to charge only the marginal cost for the use of its facilities. This method makes it easier for the small entrepreneur to avail himself of these otherwise costly facilities.

Recommendations of Task Force

Question 16: What conclusions and recommendations has NASA's Task Force for the Commercial Use of Space reached?

How do you intend to implement these recommendations? How will costs be shared for this endeavor?

Answer 16: The NASA Task Force for the Commercial Use of Space will counsel NASA on the development of the appropriate policies, programs, and research priorities to foster the commercial use of space, and on the conduct of those programs. As the Task Force has not yet made formal recommendations to the NASA Administrator, questions involving implementation and costs associated with these recommendations are premature.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS

Shuttle Pricing Policy and Space Commercialization

Question 1: Do commercial ELV's compete with the Shuttle, or do they complement the Shuttle?

Answer 1: The principle commercial ELV's, Delta and Atlas Centaur, are NASA vehicles that are being phased out of the Government inventory. To the extent that these ELV's fly customers that otherwise could have flown on the Shuttle, they are competitors, to the extent they fly payloads in excess of Shuttle capacity they are complimentary. There are also specialty markets not serviced by the Shuttle which could be served by U.S. commercial ELV's, such as Conestoga or Scout.

Question 2: Do commercial ELV's compete with Ariane? Can commercial ELV's compete with Government-supported systems?

Answer 2: Ariane is generally perceived as the main competitor of U.S. commercial ELV's. Although ostensibly a commercial entity, Ariane is government sponsored and supported. All other systems in the international arena are government developed and government operated e.g., the United States, USSR, Japan, India, China, etc. Therefore, it will be necessary in the future for U.S. ELV's to compete successfully against Government supported systems. If domestic ELV's offered the same services and launch assurances as a Government supported launch system, and could reduce their costs to be competitive with government-supported systems, then it would be possible for them to compete. Government-supported systems generally have the option of pricing at any level as a function of their policy objectives which means that they can, as a group, determine the market share they will allow domestic ELV's to maintain (other factors being equal).

Question 3: Does Ariane compete with the Shuttle? If the United States is to maintain its world leadership position in providing commercial space transportation, don't Shuttle prices have to be competitive with Ariane?

Answer 3: Ariane is the current principal competitor of the Shuttle in the international launch services marketplace. Assuring U.S. world leadership in providing commercial space transportation requires competitive national pricing of U.S. launch systems, Shuttle or domestic ELV's, with the international launch system. (Position not approved by OMB.)

Question 4: Is Ariane heavily subsidized, or did they operate in the "black" in 1984? Doesn't Ariane benefit from inherent cost advantages as well as an historically strong dollar? Does the Ariane pricing policy reflect full cost recovery?

Answer 4: Arianespace management has announced that the company showed a small profit in 1984. We believe this is in some large measure due to the current high dollar exchange rate, since most of Arianespace's non-European customers pay in that currency. Other historical developments such as the strong dollar have contributed to a highly favorable cash flow.

Arianespace does benefit from inherent cost advantages. While U.S. ELV's require three separate systems to span the full range of payload weights, Ariane accomplishes the same with only the Ariane 3 and 4. There is a great deal of commonalty between the two, and Ariane 4 spans the payload range from 1900-4200 kg (4200-9200 lbs) simply by adding liquid and solid strap-ons to a core vehicle. These design advantages, together with more modern production and launch facilities, probably all lead to significant economies.

Arianespace has characterized the announced Ariane pricing policy which will apply to ESA launches after January 1, 1987, as representing "full cost recovery." These prices are consistent with available estimates and data on Arianespace's costs. At the same time, the policy gives Arianespace free rein to discount as required to compete outside Europe.

Question 5: Is it important for this nation to have an ELV backup capability to complement the Shuttle? If so, why? If not, why? Do the recent Air Force decisions to develop a complementary expendable launch vehicle (CELV) and to refurbish Titan II's give the United States such an ELV capability?

Answer 5: An ELV capability to complement the Shuttle currently exists, and will continue to exist for an indefinite period. NASA's use of Expendable Launch Vehicles will extend through 1987, or later, in some instances, in support of reimbursable customers who had made earlier commitments to be launched by an ELV system. The Air Force decision to use surplus Titan II military missiles for space application will extend ELV capabilities into the 1990 period. In addition, the Air Force decision to develop a Complementary Expendable Launch Vehicle (CELV) also will extend our ELV capability. So, although Shuttle is being developed to accomplish our current and projected transportation needs, and is this Nation's primary Space Transportation System, some complementary U.S. ELV capability will exist for a number of years.

Options to continue ELV systems or develop new ELV systems are still open and will continue to be as requirements dictate for both the Government and the private sector.

Question 6: Should the Federal Government take steps to guarantee the survival of the domestic ELV capability such as preclude the launch of communications satellites by the Shuttle? Would such a step actually guarantee the economic viability of commercial ELV's?

Wouldn't such a policy have an adverse effect on NASA's budget?

Answer 6: The survival of commercial U.S. ELV's is dependent on their ability to compete in the marketplace with Ariane. Precluding commercial communication satellites from the Shuttle would increase Government funding requirements in that the net projected contribution of these missions to fixed cost exceed $1 billion over the next five years. Full utilization of the Shuttle, and the ability to enhance its capabilities for repair and retrieval, dictate the Shuttle launch at least some of the commercial and foreign satellites. Additionally, reduced flight rates would adversely affect existing contractural arrangements with a resultant reduction in planned savings. Such a step could also result in the destruction of the Shuttle dependent U.S. upper stage industry. (Position not approved by OMB.)

Question 7: Do commercial ELV's affect total launch demand, or do they merely affect the market shares of the Shuttle and Ariane? Is this true over the long term as well as the short term?

Answer 7: We have seen no evidence that commercial ELV's would affect total launch demand for communications satellites. The launch service demand can be considered inelastic with respect to launch availability. NASA plans to reach a launch-rate capability of 24 per year by 1989. Total worldwide foreign and commercial demand for about the next 5 to 10 years is estimated to be six to eight equivalent Shuttle flights per year. Demand is expected to grow over the long term as new capabilities and commercial opportunities are developed.

Question 8: In your opinion, what is the most appropriate Shuttle pricing policy for the 1989-1991 timeframe? What goals are associated with that policy? What would be the cost of a full orbiter payload bay under your preferred pricing policy? And, at that price would the Shuttle remain competitive with Ariane.

Answer 8: The policy of full cost recovery for STS flight operations has been established by the President in the National Space Strategy. There are many definitions of "full cost recovery" that can be applied. The Administration is considering this question at this time, and, pending completion of that activity, a more specific answer is inappropriate.

Question 9: Based on your analysis, what is the projected demand for commercial communications satellite launches for the next five years? For the next ten years? What is the existing launch capability for this same period of time? Isn't it true that, for the short term, launch capability far exceeds demand?

Answer 9: The demand for commercial communication satellite launches for the next five years is expected to average 15-20 satellites, or about 6 to 8 Shuttle flights, per year. Predictions for the total demand for the next ten years are more difficult to determine. However, we believe the demand will be in the same range. Either Ariane, the Shuttle or the privatized ELV's have, or could have, the capability to capture the entire market in the period under consideration. The frequency of Shuttle launches is increasing and NASA plans to be at 24 flights per year by 1989.

Question 10: Based on your analysis, at what level would Shuttle prices need to be set to permit commercial ELV's to compete with the Shuttle for commercial communications payloads in the 1989-1991 time period?

Would this Shuttle price level ensure the commercial ELV's ability to compete with Ariane.

Answer 10: It is questionable whether Shuttle prices alone, at any level, will ensure the competitiveness of U.S. commercial ELV's. Raising Shuttle prices to enhance the business of domestic ELV operators could also have the effect of driving customers to Ariane. Ariane's published prices (based on their estimates of full cost) cannot be matched by U.S. commercial ELV operators. Relatively high levels of prices would allow Ariane to expand production capability and "package price" launch costs with satellite manufacturing and ground support to enhance the overall competitiveness of these elements. We believe that Ariane will continue to price its services under the prices for any U.S. launch system. (Position not approved by OMB.)

Question 11: Based on your analysis, at what level should the Shuttle price be set to ensure competition between the Shuttle and Ariane in the 1989-91 timeframe?

Answer 11: The President has directed NASA to submit to the Senior Interagency Group (Space) a plan to recover full costs for foreign and commercial Shuttle operations recovery in Phase III commencing in FY 1989. A Shuttle pricing policy plan has been submitted to SIG (Space) by NASA.

At the current price of $71 million, we have been splitting the market with Ariane although, recently, they have been consistently underbidding the Shuttle. (Position not approved by OMB.)

Question 12: Besides Ariane, are any other foreign nations interested in developing and marketing launch capabilities? What is the expected time frame for these foreign systems to come on line?

Isn't it likely that these systems will receive government support?

Answer 12: Apart from Ariane, we expect Japan, the Soviet Union, and China to enter the commercial launch market. The Soviets have shown active interest in bidding on Inmarsat launches late in the decade (although they later dropped out), and have launched an Indian satellite on a partially-reimbursable basis. The Japanese have plans for a new-generation launcher in the early 1990's that would be competitive in payload class with Ariane and Shuttle, and have indicated an interest in offering it on the world market. The Chinese have openly declared that their launch vehicle will be offered on a commercial basis, probably later in this decade.

All of these prospective competitive launch systems are or will be developed by governmental organizations, and will certainly receive varying degrees of government support.

Question 13: Do you accept NASA's position that fixed-costs represent two-thirds of the total operational costs of the Shuttle if at least eight flights are flown? And, that the fixed-costs are the same for a flight rate of 8 to 24 flights per year?

Answer 13: About two-thirds of Shuttle operational costs are fixed for the number of Shuttle flights being considered through the 1980's and early 1990's, or for about 24 flights per year. Fixed costs depend on the establishment and maintenance of a launch capability as well as the timeframe in which the flights are conducted. The currently planned fixed cost requirement, for example, in the late 1980's, is not significantly different for 12 to 15 flights than it is for 24 flights. If the flight rate were to exceed the manpower and facility capability, necessitating an augmentation of service contracts and existing agreements, then the fixed costs would change.

Question 14: What is your estimate of marginal launch costs for the 1989-1991 timeframe? How did you compute that number? What is the current marginal launch cost?

Answer 14: The marginal costs of a Shuttle flight in the FY 1989-1991 time frame is estimated to be $33 million in FY 1982 dollars. This estimate reflects assessments by individual STS elements i.e., Solid Rocket Booster, External Tank launch operations, propellants, flight operations, orbiter hardware, main engine, and crew equipment. The largest elements of the marginal cost are the External Tank and Solid Rocket Booster projects. The marginal cost for these projects consist of expendable materials, touch labor, and a portion of support labor that can be changed with a change in flight rate. The remaining elements of marginal cost include the variable flight preparation and launch processing manpower. The marginal costs are not all incurred in the year of the flight but spread over a three year period leading up to launch. A decision to add or cancel a flight would have to be made two to three years in advance in order to realize these cost estimates. The current marginal cost of flights flown during FY 1985 would be about $44 million in FY 1982 dollars. The hardware to support these flights has already been delivered and the flight planning and launch processing has been nearly completed. (Position not approved by OMB.)

Question 15: What does the term "full cost recovery" mean to each of you? And, what elements would you include in this term? What elements are included in the Government's ELV full cost recovery pricing policy? Should "full cost recovery" be the principal policy objective of the Shuttle program?

Answer 15: Full cost recovery means a price that recovers the full costs of launching a given customer or class of customers. NASA believes the proper context for defining full cost may be dependent upon the use of the system and attributes of the customer being considered. NASA historically has charged out of pocket costs to other Government agencies for some uses of NASA services or products. This philosophical basis for the policy was that the user should be charged the amount of his impact on the baseline program, e.g., hardware, consumables, special overtime worked on behalf of the non-NASA user. In some instances, for example the current DOD Atlas/Centaur FleetSatCom Program, the charge amounts to the full cost of operating the Atlas-Centaur vehicle hardware and services required to conduct a launch. In other cases, for example the support to commercially sponsored ELV programs, pricing is based on a policy of recovering the additive or marginal cost of supporting these launches. There is no attempt to charge depreciation or use fees for post Government investments in capital assets used by the commercial operator. (Position not approved by OMB.)

In the case of foreign and commercial STS users, projected excess Shuttle capacity is being made available on a reimbursable basis once the Government flight requirements have been accommodated. The fixed operating costs of the system will be incurred to support the 18 to 20 Government flights per year regardless of the 4 to 6 flights available for commercial use.

Selection of the appropriate price for the levels of full cost for full cost recovery can also be dependent upon both competitive considerations and policy objectives. For example, a very high STS price that includes allocation of every possible fixed and sunk cost that precludes sale of commercial flights actually results in no cost recovery. With this in mind, NASA has recommended a full cost recovery price based on average operating cost which includes average marginal operating cost plus a pro-rata share of fixed operating cost.

Full cost recovery is a significant consideration of the STS system, however, the first priority of the STS program is to make the system fully operational and cost effective in providing routine access to space. In addition, maintaining U.S. leadership in Space Transportation and developing the commercial use of space have been established as NASA's principal policy objectives.

Full cost recovery means that NASA will recover the appropriate direct and indirect costs incurred by a non-Government customer of the STS. In so doing, NASA would recover costs for the expended (consumables) portion of the flight, such as propellants, gasses, and the large External Tank, portions of the Solid Rocket Motors; mission planning peculiar to the customer's requirements; launch site handling of the customer's payload and its integration with other customers into the Shuttle; and all training costs for astronauts and payload specialists associated with the customer's payload and other appropriate allocations of indirect costs.

Question 16: Is the Shuttle an "operational" system, or is it still in the research and development stage? Should the same pricing policy criteria apply to a "R&D" activity as to an "operational" system?

Answer 16: There are still a number of research and developmental activities associated with the Shuttle. It is in its infancy as an operational system. Generally, R&D activities have been looked on favorably and full cost recovery has not been a primary objective during this phase of activity.

Question 17: Does the maturing nature of the Shuttle program and its previous learning experiences increase the probability that future cost estimates will be more accurate?

Answer 17: Although, in programs as complex as the Shuttle, it can be expected that there will be some continuing need for redesign and improvement, the major development activities which cause uncertainty in budget projections, are completed. The operational flights to date have given us a good understanding of the mission planning and vehicle processing requirements. The hardware manufacturers have enough experience with fabrication and assembly, that now, most are under incentive type contracts.

For these reasons NASA believes the Shuttle program will continue to exhibit stability in future cost estimates.

Question 18: What influence do economic assumptions have on Shuttle pricing policy options? Does Shuttle pricing policy have any budgetary consequences?

Answer 18: The Shuttle pricing schedule submitted to the Senior Interagency Group (Space) was based on actual experiences and projected launch demands. There are budgetary consequences directly related to a pricing policy. Under current and proposed NASA prices for the STS commercial customers, the plan is to reimburse the marginal cost of these flights as well as a contribution to the fixed operating costs of the system. The runout of the NASA budget is premised on the sale of 4 to 5 commercial flights per year. The next contribution to fixed cost included in these budget runouts for customers not yet committed to the STS is 1.1 billion through 1990. (Position not approved by OMB.)

Question 19: Should Shuttle pricing policy be based on projected flight rates or projected Shuttle operational capability? In light of the National Research Council's "Assessment of Constraints on Space Shuttle Launch Rates" is the assumed flight rate of 24 flights per year in 1989 realistic for planning or pricing purposes?

Answer 19: The 1986 budget assures achievement of the 24 flights per year based on NASA's current best estimates of operational capability and future demands of all users. Shuttle pricing projections are based on both operational capability and projected demand. Achieving a flight rate of 24 per year is believed realistic in the time period under consideration. Therefore, it not is unrealistic to consider this number in determining pricing policy.

Question 20: Is it realistic to assume that the operating cost per flight will decrease from approximately $137 million per flight in 1984 to $39 million per flight in 1989? What are the principal factors accounting for these substantial economic gains?

Answer 20: The FY 1986 NASA budget projects that the average cost per flight (in constant 1982 dollars) will decrease from approximately $162 million per flight in FY 1985, based on 11 flights, to $84 million per flight in FY 1989, based on 24 flights. The Shuttle cost is, to a considerable extent, fixed. No matter what the flight rate is, the mission planning and launching processing teams have to be in place, facilities must be manned and skilled disciplines maintained. The largest single factor in reducing average cost per flight is the ability of this workforce to support higher flight rates without substantial expansion. Aiding in the cost per flight reduction will be efficiencies achieved by reducing vehicle turnaround times based on learning experience, and standardization of mission planning activities resulting from relaunching of payloads similar to those flown previously. In a similar manner, the hardware elements will be further down the learning curve but the fixed overhead at the manufacturers will be spread over a larger number of flights. With a doubling of the flight rate between FY 1985 and FY 1989, with planned efficiency improvements and with increased learning, NASA believes the $84 million average cost per flight by FY 1989 is definitely achievable.

Question 21: During the executive branch Shuttle pricing debate, are any steps being considered, related to pricing policy, that would make the space Shuttle more attractive to the commercial sector?

Answer 21: Considerable consideration is being given to permit a degree of flexibility in negotiating launch service agreements with the commercial sector and to continue the optimum use of the Shuttle in commercialization of space.

Question 22: Are the expectations of profit by the private sector in space realistic? Or, is a well-known space executive correct when he says that private sector investment in space is "overexposed," "overadvertised," and fought with "too much hype?"

Answer 22: As a research and development Agency, NASA is cognizant of the dangers of over-selling the economic and social benefits of space endeavors which are characterized by high-risks and long-term payback outlooks. NASA's mission in encouraging the commercial use of space is to build the research and development foundation for commercial space endeavors. Expectations of profit should be based on the current levels of private sector investment in commercial space ventures.

As NASA does not make economic projections of profits to be derived from commercial space ventures, judgments as to private sector expectations of profit in space are best left to the private sector. We are taking steps to help remove any barriers to the commercial development of space, in accordance with the President's policies.

Senator **Gorton**. Dr. Hanushek, again, your complete statement will be included in the record. I would greatly appreciate you summarizing it for us.

STATEMENT OF ERIC HANUSHEK, DEPUTY DIRECTOR, CONGRESSIONAL BUDGET OFFICE

Mr. **Hanushek**. I will be happy to, Senator.

Mr. Chairman, I am pleased to appear before the subcommittee to discuss space shuttle pricing policy for foreign and commercial users. The shuttle price is the key factor in determining the resources the Nation devotes to space, and whether these are provided by the public or private sector.

For instance, a high shuttle price could encourage private U.S. companies to enter the commercial launch market but would leave the shuttle underused and possibly strengthen the position of the shuttle's major competitor, Arianespace. On the other hand, a very low price would encourage the use of the shuttle but limit private competition, subsidize foreign and commercial users, and possibly encourage unprofitable expansion of the shuttle system.

The history of shuttle pricing is well-known to the Committee. Let me simply note one subtle change in pricing considerations. While it was once believed that a single price would simultaneously meet all our national space objectives, it is now clear that such is not the case.

The President is expected to submit soon a pricing proposal covering shuttle missions between 1989 and 1991. NASA has suggested a price of $87 million per flight in constant 1982 dollars that will recover average operational costs only.

In CBO's analysis of pricing policies for shuttle services, two sets of factors are considered. The first is the cost of providing shuttle services and how closely the shuttle price should be linked to the resources consumed by the use of the shuttle. The second is space policy objectives, because the shuttle price, in effect, sets priorities among conficting space goals.

In the absence of a competitive market for shuttle services, either average or marginal costs can provide a basis for determining prices. Average cost is simply the total cost of providing the services divided by the number of flights. This is frequently referred to as a full-cost measure. Marginal cost is the cost of providing one more flight. Although an additional shuttle flight entails increased costs for fuel and other expendable supplies, many other expenditures on facilities, equipment, and people are unaffected and do not enter into the calculation of marginal costs.

CBO has provided a detailed discussion of the costs in its recent study, and I will quickly summarize them here. Three elements are key in the estimation of shuttle costs: the shuttle flight rate; the depreciation rate and discount rate used to calculate annual capital costs; and the accuracy of NASA's operational cost estimates.

The CBO-based cost estimates are provided in table 1 of my complete testimony. They are all based on an annual flight rate of 24. They represent two estimates of marginal cost: A short-run marginal cost, which is $42 million; and a long-run marginal cost, which amounts to $76 million.

We also provide three average or full cost measures. First is average full or full operational cost, which is $84 million per flight. Second, full cost less research and development [R&D] expenditures, which comes to $106 million per flight. And finally, average total cost of $150 million.

The estimated marginal costs are less than average costs because the former exclude fixed costs that do not change as additional flights are flown, but the uncertainty of the estimates is worth highlighting.

As shown in the ranges in table 2 of my full statement, the base case estimate of short-run marginal costs, $42 million, lies in a range between $28 million per flight—which is roughly NASA's estimate of short-run marginal costs—and $71 million per flight.

The long-run marginal cost estimate is $76 million per flight, in a range between $62 and $105 million. The long-run marginal cost adds to short-run marginal cost an annual capital charge that reflects a $1.7 billion replacement orbiter that might be needed to service the foreign and commercial markets.

The estimated full costs are particularly sensitive to the number of flights, because fixed costs, either operational or capital, must be spread over a smaller base if flights are less than 24 per year estimated by NASA. In table 3 of my full testimony, there is an indication of the sensitivity of the estimates. For example, if there are only 12 flights instead of 24 in 1989, the average full cost increases to $258 million.

I will now turn to the relationship between shuttle prices and policy objectives. Each of the alternative cost measures could be used as a basis for shuttle prices. The choice will directly affect how well the nation's competing space objectives are met. The three objectives that we think are most sensitive to shuttle price are: Cost recovery, efficient resource use, and encouragement of commercial activities in space.

In terms of cost recovery and efficiency, economic analysis suggests that a price equal to the marginal cost of production tends to promote the efficient use of resources, which in turn suggests that prices set for government enterprises should be based on marginal costs.

But the shuttle system is not a conventional enterprise, because many of its costs remain fixed regardless of the number of flights. These high fixed costs make the goals of cost recovery and efficiency incompatible. Specifically, because of high fixed costs, the cost of providing an additional shuttle launch is significantly less than the average cost of a launch. Simply put, recovering average costs does not lead to efficient pricing, and efficient pricing does not result in full-cost recovery.

The short-run marginal cost price, $42 million per flight, sacrifices the goal of cost recovery to ensure that the shuttle has sufficient customers to maintain a high flight rate. This price forgives shuttle users from repaying the system's fixed costs, and implicitly holds full use of the shuttle to be a preeminent policy objective. A shuttle price at this level would have no net budgetary implications, as long as NASA's cost estimates are not underestimated.

A short-run marginal cost price is valid only if excess capacity exists in the shuttle system. In contrast, the long-run marginal cost price, $76 million per flight, adopts the perspective that serving the foreign and commercial market requires including the capital costs needed to expand the system, as well as the operating costs included to perform U.S. Government in the other missions.

From a budgetary perspective, the concept of a price based on long-run marginal costs provides a litmus test to help determine the need for an additional orbiter. If the shuttle is fully booked at this price, then a new orbiter could be acquired with the confidence that its users would pay its costs, already reflected in the shuttle price. But, as with the short-run marginal cost option, the advantages of a long-run marginal cost price will not be achieved if operational costs are significantly underestimated.

It is frequently presumed that, if cost recovery is emphasized, a full-cost price would best meet this goal, but this may not be the case if flight demand for the 1989 through 1991 period is misestimated. The prices of $150 million—full cost—and $106 million—full cost less development—are high enough to permit full-cost recovery if and only if 24 flights are filled and flown in 1989.

Proponents of full-cost prices point out that, if foreign and commercial users are charged less than full costs, then they will reap, but not pay for, the benefits of the past expenditures that went into the shuttle and its technology. Moreover, full-cost prices are more comparable to the cost structures faced by private operators of competitive launch services.

But it should be remembered that the demand for the shuttle could drop dramatically in the face of high-full-cost prices. Thus, paradoxically, a full-cost price could lead to the necessity of budgetary for the shuttle system.

In fact, however, revenues from the sale of shuttle services might be maximized by charging a price below the estimated average total costs.

Full-cost prices would tend to reduce long-run Government involvement in commercial space activities since they would discourage use of the shuttle and thus reduce pressures to expand capacity. Such market information might, however, give a misleading signal about the Government's appropriate role.

There are two aspects to the commercialization of space: the promotion of a private launch industry using rockets—expendable launch vehicles, or ELV's—and the support of further commercial, industrial, and communication uses of space. The former objective is aided by higher shuttle prices, while the latter, for which launch prices are a business expense, is strengthened by lower shuttle prices.

At the shuttle's conception, its low projected costs led planners to believe that it ultimately would replace ELV's, but these low costs did not materialize, and ELV's continue to be a viable option for many space payloads.

Arianespace has priced its services to be competitive with the shuttle and plans to win a third of the launch market over the next decade. Potential private U.S. ELV firms claim that both the shuttle and Arianespace charge below-cost prices and that, if the full cost of service were reflected in their prices, American ELV's would prove competitive.

The implications of a low shuttle price, such as a short-run marginal cost price, for space commercialization are mixed. The commercial ELV industry simply could not survive, and the potential entry of other nations, Japan, for example, might be discouraged. The reaction of Arianespace is hard to predict, but it would probably attempt to remain competitive.

Firms investing in shuttle-related launch technologies would benefit most. These include companies that are designing upperstage rockets to lift into higher orbits payloads which the shuttle has placed in low orbit. Investors interested in new space processing techniques would also be encouraged, perhaps overly so since the price would make no allowance for recapturing capital costs.

Without a more extensive analysis of demand and the costs of shuttle competitors, it is difficult to evaluate the relative prospects of ELV's, Arianespace, and the shuttle, should the shuttle system charge a mid-range price based on long-run marginal costs or full operating costs. Much really depends upon Arianespace's pricing policies and the launch demand that subsequently materializes.

In summary, Mr. Chairman, the choice of a future shuttle price will implicitly set priorities among national space policy objectives. No single price, as you quoted us in your opening statement, can meet all the nation's space goals.

Some objectives, such as the efficient short-term use of the shuttle's capacity and the encouragement of commercial activity in space are best met by a relatively low price; while others, such as the encouragement of a private domestic launch industry and perhaps full-cost recovery, suggest a higher price.

The new price proposed by NASA, now under review by the administration, represents an attempt to trade off these competing policy objectives.

Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF ERIC HANUSHEK, DEPUTY DIRECTOR, CONGRESSIONAL BUDGET OFFICE

Mr. Chairman, I am pleased to appear before this Subcommittee to discuss space shuttle pricing policy for foreign and commercial users. The Congressional Budget Office (CBO) has analyzed the cost of the shuttle, developed a set of pricing options, and explored the implications of these options for space policy objectives.

The shuttle price is a key factor in determining the resources the nation devotes to space and whether these are provided by the public or private sector. For instance, a high shuttle price could encourage private U.S. companies to enter the commercial launch market, but would leave the shuttle underused and possibly strengthen the position of the shuttle's major current competitor, Arianespace. On the other hand, a very low price would encourage use of the shuttle, but limit private competition, subsidize foreign and commercial users, and possibly encourage unprofitably expansion of the shuttle system.

The shuttle launch price is not of equal importance in achieving all of the nation's space objectives. Regardless of the price charged commercial and foreign customers, the shuttle system will fly at least 12 to 15 flights annually from 1989 through 1991, a sufficient number to maintain U.S. national prestige in space techology and to contribute substantially toward meeting the nation's objectives in space science research. A significant portion of the shuttle's national security mission also could probably be met with a flight rate lower than the 24 annual flights projected by NASA.

BACKGROUND

The President soon will submit to the Congress a new pricing policy for shuttle launch services provided to non-U.S. government users from 1989 through 1991.

These users are foreign governments and mature commercial enterprises requiring launch services for payloads such as communication satellites and remote-sensing satellites.[1]

The current price for shuttle launch, $38 million plus fees for capital facilities and insurance, was set by NASA in 1977 to recover all operating and production costs, including orbiters and related equipment.[2] But by the early 1980s, the shuttle program was behind its technical schedule, and the market for launch services proved substantially smaller than expected, forcing NASA to spread its costs over a smaller number of flights. Accordingly in 1982, when NASA set the second pricing policy for launches in the years 1986 through 1988, the price was significantly higher. But at $71 million, it still will not recover all the costs of the shuttle system. The Administration is now reviewing a new policy proposed by NASA for 1989 through 1991. This price—$87 million per flight—calls for the recovery of average operational costs only. It remains substantially less than the price implied by the original pricing policy to cover all operating and production costs.

In determining a price for space shuttle services, two sets of factors are considered. The first is the cost of providing shuttle services and how closely the shuttle price should be linked to the resources consumed by the use of the shuttle. The second is space policy objectives, because the shuttle price, in effect, sets priorities among conflicting space goals. But even with agreement on priorities, two major complications remain in pricing the shuttle. First, uncertainty exists about the level of demand for shuttle services four to six years in the future. Second, there is disagreement about how NASA cost estimates should be used to develop an appropriate price. As a result, the CBO analysis of cost bases for shuttle pricing includes both a base case and ranges around that base for each potential pricing option.

SHUTTLE COSTS

In the absence of a competitive market for shuttle services, either average or marginal costs can provide a basis for determining prices. Average cost is simply the total cost of providing a service divided by the number of units of service provided. For the shuttle, flights are usually thought of as the relevant unit. Marginal cost is the cost of providing an additional unit of service, or one more flight. While an additional shuttle flight entails increased costs for fuel and other expendable supplies, many other expenditures on facilities, equipment, and people are unaffected and do not enter into the calculation of marginal costs.

Three elements are key in the calculation of shuttle costs, and uncertainties about these lead us to consider ranges of cost estimates:

The shuttle flight rate. The base case assumes 24 flights for 1989.

The depreciation rate and discount rate used to calculate the annual capital charge for the shuttle's assets. The base case uses a 4 percent real interest rate and a 25-year systems life.

The accuracy of NASA's operational cost estimates and the division of operational costs between fixed and variable components. The base case uses the NASA total operational cost estimate and divides it equally between fixed and variable costs.

The CBO base case estimates, which are described in more detail in our recent report, include five alternative measures of cost (see Table 1):[3]

Short-run marginal cost, $42 million per flight—operational cost of an additional shuttle flight.

Long-run marginal cost, $76 million per flight—operational cost of an additional shuttle flight, plus the capital costs associated with providing services for foreign and commercial users.

Average full operational cost, $84 million per flight—the average total operational cost of a shuttle flight. Unlike marginal cost, it includes fixed operational costs.

Average cost less development, $106 million per flight. This cost averages all shuttle cost, except research and development, over the number of shuttle flights.

Average full cost, $150 million per flight. This measure averages all shuttle costs, both past and future, over all shuttle flights.

The estimated marginal costs are less than the average costs because the former exclude fixed costs that do not change as additional flights are flown. Uncertainty in these estimates is worth highlighting, as shown in the ranges in Table 2. The base case estimate of short-run marginal costs—$42 million per flight—lies in a range between $28 million per flight (roughly NASA's estimate) and $71 million per flight.

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[1] In contrast, so-called "infant industries" (such as materials processing and pharmaceutical manufacture) receive free or very low-cost transportation from NASA, until they approach financial self-sufficiency.

[2] All figures in 1982 dollars.

[3] Congressional Budget Office, Pricing Options for the Space Shuttle (March 1985).

TABLE 1. PRICING OPTIONS

Pricing Policy	Definition of Cost	Price Per Flight in 1989 (millions of 1982 dollars) With 24 Flights	Price Per Flight in 1989 (millions of 1982 dollars) With 18 Flights	Policy Implications
Marginal Cost Prices				
Short-Run Marginal Cost	Variable operational costs.	42	42	Maximum use of shuttle. Likely end to domestic expendable launch vehicles (ELVs). Direct competition with Arianespace. If NASA's costs are underestimated, revenues will not cover cost. High flight rate encourages future expansion.
Long-Run Marginal Cost	Variable operational costs, plus a capital charge for an orbiter dedicated to foreign and commercial flights.	76	76	Shuttle should maintain current market share and generate net federal revenues. Domestic ELV firms have little chance of success.
Full-Cost Prices				
Full Operational Cost	All operational costs. Approximation of proposed NASA policy for 1989 through 1991.	84	98	Largely the same as for long-run marginal price.
Full Cost Less Development	All operational costs, orbiters at replacement cost ($1.7 billion each), plus other investment but excluding research and development.	106	128	Shuttle will lose part of its market share unless Arianespace increases its price as well. Prospects for domestic ELVs improved but still uncertain. Less than full use of shuttle.
Full Cost	All operational costs, plus all investment valued at historic costs.	150	186	Shuttle loses all but specialized foreign and commercial payloads--flight rate will be below efficient level. Reduced net federal revenues. Domestic ELVs will do well, particularly if Arianespace increases price. Investors in new space processing may reduce planned spending. Little immediate need to expand shuttle system.

SOURCE: Congressional Budget Office.

NOTE: Estimates reflect base-case assumptions about interest rate and depreciation. Alternative assumptions would generally result in higher costs for options with capital costs. Operational costs based on estimates by NASA.

The actual cost in 1989 will depend on the flight rate between now and then and on how well NASA has estimated future operating costs and has distinguished fixed from variable costs. The base case estimate for the long-run marginal cost is $76 million per flight—in a range between $62 million and $105 million. It adds to short-run marginal cost an annual capital cost that reflects a $1.7 billion replacement orbiter, which might be needed to service the foreign and commercial market.

TABLE 2.—*Marginal cost: Range of estimates per flight*

[In millions of 1982 dollars]

Cost bases:	
Short-run marginal cost:	
Low	28
Base case	42
High	71
Long-run marginal cost:	
Low	62
Base case	76
High	105

Source: Congressional Budget Office.

Estimated full costs rise significantly as the estimated number of flights decreases, because fixed costs, either operational or capital, must be spread over a smaller base, as Table 3 shows. For example, if 18 rather than 24 flights are flown in 1989, the average full cost increases from $150 million to $186 million. With only 12 flights, it increases to $258 million.

TABLE 3.—FULL-COST PRICES UNDER VARIOUS SHUTTLE FLIGHT RATES

[In millions of 1982 dollars]

Full-cost prices	Number of flights		
	12	18	24
Average total cost, including all capital costs	258	186	150
Average total cost, less research and development	170	128	106
Average operational cost (the NASA base)	126	98	84

Source: Congressional Budget Office.

SHUTTLE PRICES AND POLICY OBJECTIVES

Each of the alternative cost measures could be used as a basis for shuttle prices. The choice will directly affect how well the nation's competing space objectives are met. The three objectives most sensitive to the shuttle price are: Cost recovery; Efficient resource use; and, Encouragement of commercial activities in space.

COST RECOVERY AND EFFICIENCY

Economic analysis suggests that competitive markets yield prices approximating marginal costs and that such prices provide for efficient use of resources. When price exceeds marginal cost, society forgoes benefits because consumers are willing to pay more for the additional unit of the service than the value of the resources that went into providing it. Conversely, if marginal cost exceeds price, resources used to produce the service would be better employed in providing some alternative good or service. Thus, a price equal to the marginal cost of production tends to promote the efficient use of our resources, which in turn suggests that prices set for government enterprises should be based on marginal costs.

But the shuttle system is not a convetional enterprise because many of its costs remain fixed regardless of the number of flights. These high fixed costs make the goals of cost recovery and efficiency incompatible. Specifically, because of high fixed costs, marginal cost—the cost of providing an additional shuttle launch—is significantly less than the average cost of a launch. Simply put, recovering average costs does not lead to efficient pricing, and efficient pricing does not result in full-cost recovery.

The short-run marginal cost price, $42 million per flight, sacrifices the goal of cost recovery to ensure that the shuttle has sufficient customers to maintain a high flight rate. This price forgives shuttle users from repaying the system's fixed costs, and implicitly holds full use of the shuttle to be a preeminent policy objective. A shuttle price set at this level would have no net budgetary implications, as long as NASA's cost estimates are correct. If costs prove to have been underestimated, however, the government could end up subsidizing foreign and commercial payloads.

A short-run marginal cost price is valid only if excess capacity remains in the shuttle system. In contrast, the long-run marginal cost price, $76 million per flight, adopts the perspective that serving the foreign and commercial market requires capital costs to expand the system as well as operating costs. From a budgetary perspective, the concept of a price based on long-run marginal costs provides a litmus test to help determine the need for an additional orbiter. If the shuttle is fully booked at this price, then a new orbiter could be acquired with the confidence that its users would pay its costs (already reflected in the shuttle price). But, as with the short-run marginal cost option, the advantages of a long-run marginal cost price will not be achieved if operational costs are significantly underestimated.

It is frequently presumed that, if cost recovery is emphasized, a fullcost price would best meet this goal. But this may not be the case if flight demand for the 1989 through 1991 period is misestimated. The prices of $150 million (full cost) and $106 million (full cost less development) are high enough to permit full-cost recovery if, and only if, 24 flights are filled and flown in 1989. In fact, revenues from the sale of shuttle services may be maximized by charging a price below the estimated average total costs.

Proponents of full-cost prices point out that if foreign and commercial users are charged less than full costs, then they will reap, but not pay for, the benefits of the past expenditures that went into the shuttle and its technology. Moreover, full-cost prices are more comparable to the cost structures faced by private operators of competitive launch services.

But it should be remembered that the demand for the shuttle could drop dramatically in the face of high, full-cost prices. Thus, paradoxically, a full-cost price could lead to the necessity of budgetary subsidies for the shuttle system. Full-cost prices would tend to reduce long-run government involvement in commercial space activities since they would discourage use of the shuttle and thus reduce pressures to expand capacity. Such market information may, however, give a misleading signal about the government's appropriate role.

THE LONG-TERM COMMERCIAL DEVELOPMENT OF SPACE

There are two aspects to the commercialization of space: the promotion of a private, domestic launch industry using rockets—expendable launch vehicles (ELVs)—and the support of further commercial, industrial, and communication uses of space. The former objective is aided by higher shuttle prices while the latter, for which launch prices are a business expense, is strengthened by lower shuttle prices. The price that any user ultimately must pay depends importantly on the alternative suppliers in the launch market, and therefore CBO has concentrated on this element of commercialization.

At the shuttle's conception, its low projected costs led planners to believe that it ultimately would replace ELVs. But these low costs did not materialize, and ELVs continue to be a viable option for many space payloads. Currently, the shuttle's ELV competitors include Arianespace (an enterprise backed by the 11 nations of the European Space Agency) and, potentially, several private U.S. firms. The ELV industry offers launch services with rockets directly or indirectly developed by U.S. government efforts—Delta, Atlas Centaur, Titan and their European relative, Ariane. Arianespace has priced its services to be competitive with the shuttle and plans to win a third of the launch market over the next decade. Potential private U.S. ELV firms claim that both the shuttle and Arianespace charge below-cost prices and that, if the full cost of service were reflected in their prices, American ELVs would prove competitive.

The implications for space commercialization of a very low shuttle price, such as a short-run marginal cost price, are mixed. The U.S. commercial ELV industry simply could not survive and the potential entry of other nations (Japan, for example) might be discouraged. Although the response of Arianespace is hard to predict, continued subsidies by its European supporters appear likely. As a result, the commercial market would probably continue to be shared between Ariane and the shuttle, with the shuttle gaining some relative advantage.

Firms investing in shuttle-related launch technology would benefit most from a very low price. These include companies that are designing upperstage rockets to lift into higher orbits payloads which the shuttle has placed in low orbit. Investors interested in new space processing techniques would also be encouraged, perhaps overly so since the price would make no allowance for recapturing capital costs.

Without a more extensive analysis of demand and the costs of shuttle competitors, it is difficult to evaluate the relative prospects of domestic ELVs, Arianespace, and the shuttle, should the shuttle system charge a midrange price based on long-run marginal costs or full operating costs. While a shuttle price based on long-run marginal costs might be low enough to allow NASA to compete effectively with Arianespace, it could be too low to permit domestic ELVs to survive. alternatively, under a higher price based on full costs (and perhaps a full cost less development price), the U.S. ELV industry could compete directly with Ariane and the shuttle. Although existing ELVs firms (those using the Delta and Atlas-Centaur rockets) would have a difficult time matching Arianespace's price, they would have real incentives to invest additional funds in improving these rockets or in developing new ones. From this prespective, a competitive domestic launch industry would be best promoted by launch prices that reflect full costs, unsubsidized by governments.

Proponents of charging a higher shuttle price to encourage a private domestic launch industry contend that the benefits of a strong private industry are not limited to launch privatization. According to this view, a private launch industry would enhance national security and would provide lower launch costs in the long run, thus encouraging all types of space commercialization. Lower launch costs presumably would be realized by superior private-sector cost control and technical innovation stemming from competition in the marketplace.

These benefits could be jeopardized, however, if Arianespace undercut a full-cost shuttle price with a subsidized predatory price. If investors preceived that Arianespace would use its government subsidies to prohibit the entry of U.S. ELVs, then the development of the U.S. ELV industry could be thwarted. thus, in addition to a higher shuttle price, an aggressive trade policy that sought to eliminate Ariane subsidies might be a necessary precondition to investment in U.S. ELVs.

OTHER FACTORS

A significant aspect of pricing policy concerns the time for which the price remains in effect. NASA has proposed a three-year policy, covering 1989 through 1991. The rationale is that price stability is desirable from a marketing standpoint and that the detailed engineering and construction work on communication satellites must start at least three yers before launch. A very long lead time, such as the six years from now until 1991, however, greatly increases the likehood of errors in forecasting costs and demand. One alternative to the proposed policy would be to establish a pricing principle, use it to set a price for 1989, and then to update the price each year using NASA's most recent information on costs and flight rates. This policy would implicitly have foreign and commercial users share a portion of the risk with the U.S. government.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question 1. Dr. Hanushek, what Shuttle pricing policy will most effectively serve to maximize the U.S. share, be it that of the Shuttle, or a domestic ELV industry, or some combination of the two, of the world satellite launch market?

Answer. Very low prices, of course, would ensure the fullest use of the shuttle, but they would not maximize U.S. revenues from the foreign and commercial launch market. It is difficult to estimate which shuttle price would result in the largest U.S. share of world launch revenues. Such calculations would require detailed analyses of the demand for launch services from 1989 through 1991 and of the probable responses of Arianespace to alternative shuttle prices. CBO has not undertaken such analyses.

Based on the information CBO has gathered, it seems unlikely that a shuttle price set high enough to allow a private domestic ELV industry to develop would also maximize the U.S. share of total launch revenues. The price that would do this would most likely fall somewhere between short-run marginal costs ($42 million in 1982 dollars) and full costs less R&D ($106 million). But the exact level that price cannot be ascertained with available information.

Question 2. Dr. Hanushek, in this ongoing debate, it has been suggested by some interested parties that a multi-tiered pricing policy which charged the nascent space processing industries marginal costs and the communications satellite owners full costs might be appropriate.

Whate are the implications of such a policy, and what is its likely impact on the allocation of the satellite launch market?

Could you comment on the merits or faults of incorporating in a pricing policy a royalty fee that is based on the income generated from activities such as space manufacturing that require Shuttle launch services?

Answer. The current pricing policy is, in effect, a two-tiered structure with a zero price charged for certain classes of payloads. Its purpose is to lower the cost of experimentation to firms with new space technology applications, like materials processing. NASA now provides this type of access to space through Joint Endevour Agreements (JEAs). It is NASA's intention that once operational status is achieved, JEA experimenters will pay full price—that is the price charged to other operational users such as communications companies. If, however, firms testing new space applications were charged marginal costs, many experiments simply would not be conducted because of the expense, combined with their inherent riskiness. Thus, the suggested policy would limit the amount of experimentation relative to the current policies.

In the pricing period under discussion, 1989-1991, none of the active experiments in materials processing (with the possible exception of the McDonnell Douglas/Johnson and Johnson venture) are close to an operational phase. The market of paying customers is limited to communications satellite and, perhaps a small number of remote sensing payloads. If a full-cost price were charged for these operational payloads, the CBO study concluded that the shuttle would have significant excess capacity, U.S. ELVs would be able to enter the market; but, as indicated above the U.S. share of the world launch market would likely be smaller than under lower prices.

Relative to the current JEA arrangement, royalty pricing would ensure that the government received a share of any windfall profits resulting from its initial subsidy of space transportation costs and, thus, would recoup a portion of the costs associated with providing such launch services. Conceptually, the royalty is no more effective than the present JEA arrangement in lowering the risk of space processing experiments. A secondary benefit of royalty pricing for private firms is that a portion of the uncertainty surround future shuttle prices would be removed for as long as a specific agreement was in place. This particular benefit could be secured in several alternative ways, however—for example, establishing and adhering to a marginal or full-cost pricing policy.

A royalty-based pricing policy shares many of the problems brought up in the current pricing policy discussion and creates several new problems. The questions of cost recovery and efficient use of the shuttle system would not be resolved by royalty pricing. In formulating the government position for the royalty level, negotiations decisions would have to be made concerning how much of the shuttle costs to recover in royalties, how much of the shuttle system capacity would be used, how to pick and choose among different shuttle users seeking experimental "free" flights, and how to respond to foreign competition.

New problems created by royalty pricing include the ownership like position conferred on the government by its sharing directly in the profitability of particular products or processes; the disincentive to private innovation posed by lowering the expectation of large additional profits resulting from space-based innovations; the sharing of costs among NASA, DOD, and foreign commercial flights; and, the more general uneasiness of some potential innovators to enter into a quasi-partnership with the government.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS

Question 1. The CBO Report indicates that through FY 1984 approximately $20 billion in outlays were invested in shuttle system capital assets (design, development, testing and engineering, construction of facilities, production of orbiters and system capability). This figure represents 79 percent of the approximately $25 billion spent on the shuttle system in that period.

If the shuttle system were a private business or a regulated utility, how would this capital investment be recouped? Do government services normally recoup the costs associated with such capital investments or do they just write off those costs?

Answer. The shuttle is a high fixed-cost investment with many of the characteristics of what economists call a "natural monopoly." A striking characteristic of a natural monopoly is the conflict between economically efficient marginal cost pricing and full-cost or average total cost pricing. Were an unregulated private firm to operate the system, it would have to charge too high a price to maximize its profits (and cover its costs) compared with a price that would lead to efficient use of society's resources. It is improbable, however, that a private firm would have invested in the shuttle system for several reasons: it is too risky; probably will pay off only in the long run; and likely will produce benefits that cannot be reflected entirely on the balance sheet of a private firm. In short, it is a reasonable candidate for public rather than private investment.

In similar cases, the government has undertaken risky, high fixed-cost investments and been willing to "write off" the cost, as you put it. Demonstration nuclear reactors are an example. In other cases in which the degree of riskiness and uncertainty was less—for example the national highway system—the government has recovered the cost of its initial investment, through a variety of taxes and user fees.

In response to the first part of your question, if a private business had invested in the shuttle system and was ultimately to be profitable, it would have to charge a price sufficient to cover its investment costs. It is not always possible, however, to find a price that recoups all investment costs, either because the originial investment costs were underestimated or the demand for the product was overestimated.

Question 2. There is an excellent discussion in your report of the history of shuttle pricing and of the transitions that have occurred in pricing policy philosophy.

It is fair to say that during the Phase I Shuttle Pricing Period (1981–85) the pricing policy goal was to recoup the total capital investment and to function as a private business? What caused the dramatic change in policy from Phase I full cost recovery to the current Phase II "out-of-pocket-cost" formula (1986–88)? What is driving the reestablishment of full cost recovery as the Phase III (1989–91) pricing policy concept?

Answer. It is fair to say that Phase I pricing policy was designed to recover at least the full cost of foreign and commercial service. Without more background than is currently available, it is difficult to say whether or not the user fee of $4 million plus attached to the Phase I price was intended to cover the average or marginal capital cost of serving the foreign and commercial market.

The dramatic price increase mandated by the Phase II Pricing Policy is necessary because the cost of the shuttle system was significantly underestimated. According to the General Accounting Office (GAO) about half of the cost underestimating resulted from failure to anticipate design changes, added requirements, and just bad cost estimating. The other half of the underestimation came from overestimating the number of flights to be launched over the first 12 years of shuttle operation. The exclusion of capital costs and other charges from the Phase II "out-of-pocket" pricing formula was presumably undertaken to maintain the competitiveness of the shuttle relative to ELVs, most prominently represented in 1982 by the impending entry of Arianespace into the launch business.

Use of full cost recovery for Phase II pricing appears related to a desire to open the launch market to U.S. private firms that would compete with Arianespace and the shuttle.

Question 3. Could you please give the Committee an indication of how many other federal programs are based on "full cost recovery?" Is the concept of "full cost recovery" recognized throughout the government as consisting of certain fundamental elements, e.g., does it include all R&D expenditures, capital investments, depreciation, rate of return on money, insurance costs, etc.? Or are there several different operating definitions of full cost recovery?

Answer. The government prices the services it provides private parties in a variety of ways. Some of these were analyzed in a CBO report, Charging for Federal Services (December 1983), which I am enclosing.

Both in intent and actual fact, federal pricing policies span the range from full-cost or average total cost pricing to marginal cost pricing, to outright subsidy. Although the current shuttle price is intented to approximate full cost recovery, in actual fact it is closer to marginal cost. The government's investment in the Interstate highway system has been fully recovered in the form of a variety of user fees and taxes. Air traffic control is another area in which full cost recovery is both intended and has been achieved, but in a way that has left general aviation users paying fees far lower than the average total cost of service provided them. Western water prices are closer to marginal cost than full cost. Other programs price governmental sales at competively established market prices, and these prices often tend to approximate marginal costs. In general, there is no government-wide definition of full cost nor is there necessarily a preference for full-cost pricing.

Question 4. What is the current pricing scheme for U.S. government ELVs used to launch foreign or commercial payload? What elements are included in this definition of "full cost recovery?" Does Ariane's price include a "capital charge?"

Answer. In the past, the government has charged foreign and commercial users the cost of the vehicle launch plus a fee for use of facilities. According to our current understanding, private ELV firms would procure launch vehicles directly from suppliers and pay a fee for the use of government facilities. We further understand that fees would be based on the marginal costs of using the facilities.

Arianespace uses a method similar to the Phase II shuttle pricing policy, to relate prices to cost; but, because of its semiprivate nature, it enjoys a great deal more flexibility than NASA in bidding for particular contracts. Although CBO has not made a detailed study of Arianespace's cost and pricing policy, we did gather sufficient information while preparing the shuttle study to draw some preliminary conclusions. Like the shuttle, Ariansepace has had different pricing policies over time. In its first pricing policy for launches through 1986, cost were reflected in "list" prices to the extent that the cost of hardware and launch services were covered. Its second pricing policy, to take effect in 1987, will include similar charges for the new Ariane 4 launch vehicle, but like the Phase I pricing policy, facilities and R&D cost are not fully covered. At the moment, we can say that Arianespace's list prices probably do not cover "full cost" defined as average total cost inclusive of R&D and all capital facilities.

It has been claimed that the Arianespace subsidy is even deeper than some facility and R&D costs because Arianespace will discount its list price in order to win a specific bid. Arianespace has indicated that it sometimes bids under costs, but that this practice is consistent with that of most private firms in competitive markets. Indeed, the tendency of high fixed-cost businesses to cut prices down to operational costs is well-known. The counter to this claim is that Arianespace enjoys the benefits of the protected European government market (as the shuttle does the U.S. government market). Thus, rather than discounting in the face of competition on individual bids, Arianespace has a two-tier pricing policy, in effect subsidizing its foreign and commercial market operations by charging its public sector clients a higher than cost price. We do not have sufficient evidence to say whether claim or counter-claim is correct.

Question 5. Let me if I might, pose several questions to you about the concept of full cost recovery and shuttle pricing policy.

First, are the efficient use of the shuttle and the encouragement of commercial activities in space compatible with full cost recovery?

Second, if one were to define full cost recovery as "operating without subsidies," which of the five CBO pricing options would meet the test?

Third, if one accepted one of the two marginal cost pricing schemes as full cost recovery, what factors would most influence whether or not the post-1988 shuttle price estimate would be accurate? To phrase this question another way, why does CBO's report see a short-run marginal price range of between $28 and $71 million per flight and a long-run marginal cost range of between $62 and $105 million in 1989?

Fourth, what factors most influence the estimating accuracy of the three post-1988 shuttle pricing options CBO describes as full-cost prices?

Answer. As we have defined full cost recovery—recovery of the average total cost of the service provided—any of the full-cost prices would probably leave the shuttle with excess capacity that could have been sold on the market for a price sufficient to cover the added, or marginal, cost of providing the service. Thus, economically efficient use of the shuttle would not be realized under a full-cost pricing policy.

There are many ways to define "subsidy." The most appropriate in relation to government service is probably a price that does not cover the marginal costs of commercial operations. Defined as such, only the low end of the range of short-run marginal costs would be unlikely to cover cost. Each of the other alternatives would be likely to generate revenues in excess of the cost of providing the additional service even if, for what ever reason, NASA has underestimated the operating cost of the shuttle system. At the very highest of full-cost pricing might be tautologically commercial and foreign users since demand, and commercial operations, might fall to zero.

The NASA estimates of cost, as well as those provided by private parties like Transpace Carriers, Inc., other segments of the government, and CBO, might sometimes, add an air of false precision to the shuttle pricing discussion. To date, the shuttle has flown only 16 times and has experienced more than a little difficulty in meeting its cost and schedule goals. The cost analysis attempted in CBO's report is, for this same system, some four years and over 150 flights in the future. The uncertainty about the cost and flight rate estimates provided by NASA has led us to place such broad ranges around our cost estimates.

It can be said more certainly that the economics of the system are accurately portrayed in the CBO report. The shuttle is a high fixed-cost system in which the marginal cost of an additional flight will be significantly less than the average total cost or the full cost of the service provided. It is this characteristic of the system which allows us to be confident that the upper bounds of both marginal cost estimates—$71 million for the short-run estimate and $105 million for the long-run estimate—are sufficiently high to capture increases in cost attributable either to underestimated costs or to lower than expected flight rates between now and 1989. It should be noted that the flight rate in 1989 will not significantly effect the short-run marginal cost estimated for that year if at least eight flights are flown.

The full-cost estimates are affected by all the factors influencing the marginal-cost estimates. In addition, these estimates are influenced by the discount and depreciation rates chosen to calculate the system's capital charges. The annual flight rate is the most significant determinant of the full, or average total, cost of service provided, however, because of the high fixed-cost of the shuttle system. A significant portion of the capital and operating costs of the shuttle system will be incurred in any given year if at least eight flights are flown. Fixed costs per flight fall as they are averaged over more flights, or increase as they are averaged over fewer flights. The shuttle system has borne these costs in the past or will pay them in the year in which launches are flown, regardless of whether the shuttle flies eight flights or 24 flights. The current cost to the government of launching more flights is reflected by the marginal rather than the full-cost estimates.

Question 6. The CBO report includes a most telling footnote:

"By using the NASA operations cost data for 1989-91, this analysis (the CBO Report) accepts the NASA estimates of the annual flight rate and of the fall in the per unit cost, or learning curve, associated with the growing cumulative volume of shuttle flights. As indicated in Chapter 1, there is reason to suspect NASA will meet its flight rate goals which will in turn push the cost of major operational expenses above projected levels."

Is it fair to say that it is unlikely that NASA can meet both its flight rate of 24 flights per year in 1989 as well as achieving its learning curve cost efficiencies? In what manner is this "doubt factor" included in the CBO pricing options?

Answer. Our study did not undertake a detailed analysis of NASA's learning curve estimates. It appears, however, that the NASA estimates of the per flight cost of major operational cost components fall most over the next 35 flights, and that learning economies are less as the cumulative number of flights increases above 50. This implies that the bulk of savings attributable to learning would be present in 1989 even if the flight rate were somewhat lower than expected from 1985 through 1989. This, of course, presumes that NASA suppliers will provide major items, such as the external tanks and the solid rocket boosters, at prices reflecting these cost improvements.

The doubt factor associated with the flight rate, and other concerns, are reflected in the CBO analysis by the ranges surrounding the base case marginal-cost estimates. The full-cost estimates incorporate doubt concerning the flight rate to the extent that estimates are shown for a lower than expected flight rate in 1989.

Question 7. The CBO report includes a table that reflects actual and projected spending on the shuttle system (Table 2). According to this table fixed cost investments basically end by FY 1988 at which point shuttle operating costs become over 95% of the system costs.

Does this projected spending table make any assumption about the procurement of a fifth orbiter?

What about additional research and development activities on the shuttle to increase capability, improve performance, etc.?

Is it safe to assume that no additional capital investments will be required in the short-term for the shuttle system? What about over the long term? Should any shuttle price include a "capital charge" to offset these future capital expenditures?

Answer. Space shuttle projections in the CBO baseline.

The CBO budget projections include two accounts that deal solely with the space shuttle. One account estimates the budget authority and outlays associated with the completion of the fourth shuttle orbiter and the inventory of orbiter spaces. These estimates are based on NASA's projections of funding requirements. The other account estimates all other shuttle operation and production requirements by inflating the fiscal year 1985 requests. Production of a fifth orbiter is not included. Shuttle-associated research and development efforts are estimated in the same manner as the operation and production account discussed above. The major research and development activities included in this projection are for continued development of the space shuttle's main engine. The CBO projections cover anticipated short-run new investment in the shuttle. CBO has not addressed the question of additional long-term investment in the shuttle.

A capital charge is included in the long-run marginal cost price and in all the full-cost prices, to cover all or part of the cost of capital used in providing service to the foreign and commercial market. If the goal of establishing a pricing policy is to encourage efficient use of resources and, if capital costs are incurred in providing additional service, then a capital charge would be part of any shuttle price.

Question 8. Despite the fact CBO papers do not make recommendations, your report does hint strongly for several policy changes including:

a. only establish a price for 1989, not for the 1989–91 period, and then update the price annually using more recent cost estimates and flight rates;

b. allow NASA some degree of pricing flexibility; and

c. change NASA's payment policy to help offset the higher price.

What factors influenced CBO's decision to discuss these matters? Were any other pricing policy changes considered by CBO?

Answer. As our report and testimony indicate, a great deal of uncertainty surround's estimated shuttle costs. This uncertainty should decrease as more flights are flown. At such time, more accurate estimates could be made about shuttle costs. One option might be to extend the Phase II price through 1989, and reconsider the entire issue next year. Such an extension, however, would create a very difficult situation for commercial ELV firms and would not solve the problem of ordering space policy objectives.

The price flexibility question is complicated by the space policy objectives question. If the objective of providing NASA with price flexibility is to make the shuttle more competitive with Ariane in particular bidding situations, one type of flexibility is required. If, however, the purpose of flexibile pricing is to force NASA to allow room for private EVVs to develop, more than a range of prices will be necessary. Specifically, a mechanism needs to be devised to provide NASA with incentives to set prices closer to full cost in those markets in which private ELVs have possibilities.

The intent of the suggestion about payment terms was to allow NASA to offer as attractive terms as possible without providing "under the table" subsidies, as some observers have indicated are provided by Arianespace in conjunction with the aggressive trade financing offered by some European governments.

Question 9. Finally, could you please indicate what effect, if any, the five pricing policy options CBO assessed would have on the budget?

Answer. The answer depends on how the demand for shuttle launch services responds to shuttle prices, and on the accuracy on NASA cost estimates.

Operating costs are the only shuttle costs sensitive to the foreign and commercial flight rate actually expended in the year that shuttle flights are made. The CBO base case assumes that half of annual operating costs will be incurred, regardless of whether or not a single commercial payload is flown, if the shuttle flies at least eight times to service government demand. Thus, if NASA's cost estimates prove correct, charging short-run marginal cost should produce at least a zero budget effect because the additional cost of each foreign and commercial pay load will be covered. In fact, charging a long-run marginal cost price could produce a budget surplus in the shuttle account, if a fifth orbiter proves unnecessary.

Long-run average cost prices could, in theory, produce a sizable surplus. The problem is that, if full-cost prices are charged, then shuttle users might switch to alternate launch sources, such as Arianespace or private ELV firms. If a higher, full-cost price leads to major reductions in demand, a plausible circumstance, then a full-cost price might have a paradoxically negative effect on shuttle revenues.

Senator GORTON. Thank you, Mr. Hanushek.

Now if we could have Ms. Dorn and Mr. Gillam back. Each of you, I understand, has an individual statement on this subject, so we will hear from you now, in this case Mr. Gillam first, and then Ms. Dorn.

STATEMENTS OF ISAAC T. GILLAM, IV ASSISTANT ADMINISTRATOR FOR COMMERCIAL PROGRAMS, NASA; AND JENNIFER DORN, DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION, DEPARTMENT OF TRANSPORTATION

Mr. GILLAM. Thank you, Mr. Chairman.

Mr. Chairman and distinguished members of the subcommittee, the President has directed that a pricing plan for full cost recovery for space shuttle operations in the post-fiscal year 1988 period be developed. This activity will have a broad impact on the U.S. maintenance of its role as a world leader in providing transportation to space.

There have been many times that we have been faced with such critical decisions during the development and evolution of the Nation's civil space program. This is one of those times. We look with pride to what this Nation has accomplished in space thanks to prudent decisions.

We planned and successfully accomplished challenging feats such as landing men on the moon, exploring the planets, and developing the space shuttle. We have also been instrumental in the development of communications satellites, expendable launch vehicles, weather satellites, and satellites for mapping Earth resources. We are now looking forward to new challenges like planning and development of the space station and further involvement of the commercial private sector in space. NASA has always been the world leader in space science research, space transportation, and the spinoff of high technology to assist domestic industry to maintain its competitive edge.

We now see emerging strong and vigorous competitors in the world space business, including satellite manufacturing and space transportation. We intend to continue to compete vigorously and successfully using the space shuttle transportation system to meet existing launch needs and to stimulate whole new industries. Some of the experts predict that by the year 2000 the space business will grow to $60 billion, with over $40 billion in materials sciences, $15 billion in communications, $2 billion in on-orbit services and remote sensing, and $1 billion in launch services.

We are at a crossroads in our decisionmaking process which will have an impact on key areas through the end of the century. In addition to providing almost three-quarters of a million jobs, the aerospace industry has been one of the outstanding performers in our balance of trade picture. In the last year aerospace exports exceeded by over three times the value of imports. Overall, the industry contributed over $10 billion in trade surplus to help alleviate our balance of payment deficit.

Fundamental issues are being debated that impact not only on the expendable launch vehicles and shuttle programs, not only NASA and Arianespace, but also the existing commercial space industry. This industry is comprised of shuttle upper stage and component manufacturers, satellite and platform manufacturers, companies such as Johnson & Johnson and 3M, which are seeking to develop new industrial processes dependent upon space shuttle flight and entrepreneurs hoping to privatize the ELV's which NASA will be discontinuing.

The question of shuttle pricing also impacts the U.S. tax base, revenues to the U.S. Government, the U.S. balance of trade, and most importantly, the American taxpayer. The President has directed that NASA's first priority is to make the space transportation system fully operational and cost effective in providing a routine access to space.

We are also working to implement the administration's goals for the commercial development of space. We are intent on ensuring that we help provide the opportunities to American industry so that we can compete effectively and we can retain as a nation a substantial share of the forecasted $60 billion commercial space business of the future.

Thank you, Mr. Chairman.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS

Commercial Programs Justifications

Question 1: On February 26 the Committee requested additional budget justification material for the Office of Commercial Programs. When will that material be submitted, and when will the Committee receive a "detailed" breakdown of your FY 1986 request? At a time of fiscal restraints, why should the Committee increase your funding from $8.5 million in FY 1985 to $30 million in FY 1986 for commercial programs? What are the current and projected staff levels of your Office? Does your Office have enough people with hands-on business experience and commercial backrounds to make this program work?

Answer 1: NASA provided the Committee with a "detailed" break down of the Commercial Programs FY 1986 budget request, in both spreadsheet and narrative (Fact Sheet) formats, prior to the Committee's oversight hearing on March 27, 1985. Copies of this information are attached.

The FY 1986 funding request of NASA's Office of Commercial Programs was developed to strengthen the research and development foundation that will stimulate industry-funded commercial product development. The increase in commercial programs funding from FY 1985 to FY 1986 is a modest one given the current levels of private sector investment in Shuttle-related commercial space ventures ($250 million +) and the minumum funding level that was recommended to the White House by an industry Working Group ($60 million). Reductions in proposed funding levels will slow NASA's efforts to build the research foundation that will provide the impetus to commercial space investment.

There are currently 30 employees assigned on a full-time basis to the Office of Commercial Programs. The projected full-time equivalent (FTE) size of the NASA staff has been set at 36. Of the 30 employees assigned, 22 were transferred into the Office through the transfer of function process. Of the 8 that have been hired, several have hands-on business experience while others posess both Masters Degrees in Business Administration and engineering degrees. Civil service rules require a substantial amount of time to hire non-civil service personnel. Because of this fact, NASA's first priority was to assemble those skills necessary to accomplish priority policy objectives such as experience in government contracting, materials science, etc.

Commercial R&D

Question 2: In recent testimony before the House Science and Technology Committee you indicated that the bulk of the $30 million FY 1986 Request was for commercial research and development. Would you please tell the Committee the exact figure proposed for commercial R&D, what activities will be funded, and what facilities (space laboratory equipment) are to be acquired for the money? Will NASA or industry decide what R&D needs to be done? How much of the R&D money will be for in-house activities? Will the creation of this program in any way effect the level of support NASA gives to the Small Business Innovation Research Program? Or are these totally different pots of money? Are the perceived commercial programs meant to be shuttle related, space station related or related to commercial free flyers?

Answer 2: The entire $30 million requested in FY 1986 for NASA's Commercial Use of Space program will be for research and development activities. If one wishes to consider the outreach and support effort as a non-research activity the amount becomes about $29.0 million of the $30 million. The following initiatives have been proposed to expand the amount of NASA research with commercial space applications and increase the commitment of industry resources to commercial space endeavors:

- o Centers for the Commercial Development of Space
- o Stimulating NASA Research with Commercial Potential
- o Stimulating Private Sector Commercial Research
- o Increasing the Availability of NASA Facilities and Equipment
- o Outreach

With the exception of Outreach, these FY 1986 initiaitves will support space and space-related research having high potential for commercial applications. Specific facilities and equipment for which FY1986 funding has been requested include:

- o Automated Protein Crystal Growth Device
- o Recirculation Isoelectric Focusing Device
- o Optical Fiber Production Device
- o Advanced Automated Directional Solidification Furnace System
- o Electroepitaxial Crystal Growth Furnace
- o Long Duration Exposure Facility II

To the extent that NASA funding will be "leveraged" with private sector resources, both NASA and industry will determine the direction of commercial space research and development. Although $5.8 million of the $30 million requested in FY1986 will support in-house NASA research with commercial potential, NASA will require this funding to be "leveraged" with private resources.

The establishment of the Commercial Use of Space Program within the NASA budget will in no way affect the support given to the Small Business Innovative Research Program. The Office of Commercial Programs is examining the use of the Small Business Innovative Research Program procedures for involving small business in this effort.

Commercial space initiatives requiring space flight and currently under consideration by the Office of Commercial Programs are primarily Shuttle-related. The Commercial Programs Office anticipates involvement in programs that are both Space Station-related and related to commercial free flyers.

Centers for Commercial Development

Question 3: In your statement you indicate that it is your intention to fund 3 to 6 Centers for the Commercial Development of Space at a rate of $500,000 to $1 million per year begining in FY1985. Is this the total number of Centers that you intend to fund, or is this the first wave? Why is your FY 1986 Request for Commercial Centers $6.5 million if the total range of funding required is between $3 million to $6 million? (6 Centers at $500,000 each or 6 Centers at $1 million each.) Will these Centers be distributed geographically or does Evaluation Factor 2 in the Request for Proposal dismiss this concern? Will an "exceptional" proposal receive special treatment, or is the cap on Federal participation in any one Center $1 million?

Answer 3: The Centers for the Commercial Development of Space Notice of Opportunity indicated that from three to six Centers will initially be funded with up to six additional Centers being funded in a subsequent proposal submission process. The actual number of Centers funded in this second gruip will depend on the number of quality proposals received and the availability of Office of Commercial Programs funds.

The geographical location of the proposed Center will be a minor criteria in selecting proposals. We will evaluate the Center's location in regard to amount, nature and vigor of surrounding industry pertinent to the research area. There will be no concentrated or specific attempts during the selection process to geographically distribute the Centers.

Proposals may be funded for more than $1 million if they are indeed "exceptional". The $6.5 million requested in FY1986 allows for this possibility as well as allowing some funds to cover the costs associated with administering the Centers by NASA. Additional new Centers not funded in FY 1985 will be funded in FY 1986.

Question 4: In the RFP for Centers for the Commercial Development of Space, NASA has identified 12 primary research areas which may lead to commercial space ventures. Will proposals be accepted in areas other than those identified by NASA? Were these areas recommended by the private sector or university research communities? Will NASA permit any duplication in the Centers, i.e. two Centers both dedicated to materials processing? How can one determine whether or not the research is directed to projects with "commercial potential" if no marketing or investment feasibility plan has to be submitted with a proposal?

Answer 4: Proposals may be accepted from research areas other than those mentioned in the solicitation. The 12 areas were recommended by government, industry, and university research personnel. NASA will allow for the duplication of proposals in generic areas such a materials processing. In the Office of Commercial Programs review of proposals submitted in response to the Notice of Opportunity, factors such as marketing or investment feasability planning will be taken into consideration.

Microgravity Research Centers

Question 5: Last Fall NASA's Microgravity Research Division established two Centers of Excellence -- one in Philadelphia and one at the University of Arizona. How do the selection criteria and funding constraints for these Centers of Excellence compare to those for the commercial centers? For example, how do you determine when protein crystal growth research is "scientific" or "commercial" in nature?

Answer 5: The Centers of Excellence administered by the Microgravity Research Division were established to develop and promote the research and technology base. The Centers for the Commercial Development of Space being established by the Office of Commercial

The Centers for the Commercial Development of Space being established by the Office of Commercial programs will promote the development of new products. Funding for the "commercial" Centers will be contingent on the commitment of industry resources--with the objective being to accelerate the movement of technology from the laboratory to the marketplace. Although parallel research activities may occur in the "scientific" and "commercial" Centers, the strong emphasis on industry participation in the "commercial" Centers will serve to generate products and processes with greater potential for commercial applications.

ELV Privatization

Question 6: Switching hats for a moment, your Office is the focal point for commercialization and privitization efforts at NASA. What is the current status of NASA's efforts to privatize the Delta, Atlas Centaur and the Scout ELV systems? What are the major stumbling blocks for each of these activities? Which firms have expressed an interest in the Scout system, and is the "selection process" still on-going or in effect has it come to a standstill because there's no perceiveable market? Why is it taking so long to finalize an agreement with General Dynamics when there was only one outstanding issue six months ago? Have recent "pessimistic" payload launch market projections dissuaded firms formerly interested in privatizing government ELVs?

NASA has been involved in discussions with Shuttle America concerning a variety of shuttle-related options -- marketing rights for the shuttle, buying or leasing an orbiter, funding a fifth orbiter. What is the current status of NASA's discussions with Shuttle America, and what items, if any, are still being discussed? Has NASA foreclosed the Fifth Orbiter option with Shuttle America? If so, why? What are the five criteria NASA is using to assess the Shuttle America proposals? Based on the Landsat experience, isn't it obvious that any privatization or commercialization activities concerning the shuttle would involve legislation.

Answer 6: NASA has been proceeding with the necessary steps to transfer operation of the Delta, Atlas/Centaur, and Scout expendable launch vehicles (ELV) to the private sector.

A formal agreement between NASA and Transpace Carriers Incorporated (TCI) for the transfer of marketing and production responsibilities for the Delta launch vehicle was signed last year. NASA recently granted TCI a fourth extension of that original agreement. Negotiations with General Dynamics, which has expressed interest in becoming the commercial operator of the Atlas/Centaur Program are still in process. Inquiries have also been received for the Scout vehicle, but the selection process for a private sector operator has not yet begun.

NASA and Astrotech have engaged in several discussions over the past 12 months regarding Astrotech's interest in making a capital investment in the Space Transportation System. Over that period of time, Astrotech has submitted for NASA's consideration and analysis "Terms and Conditions" relecting three separate concepts Astrotech has developed to serve as a basis for possible subsequent agreements with NASA. NASA has rigorously analyzed each of these two concepts and briefed Astrotech on the results of its analysis. Astrotech fully agrees that the NASA analysis demonstrates the extent to which the Astrotech Terms and Conditions in each case were not in accord with elements of NASA's Commercial Use of Space policy and broad NASA guidelines regarding potential private sector capital investment in STS. Those guidelines are as follows:

1. Any agreement between the Government and a private sector proposer to purchase an Orbiter or otherwise make a capital investment in STS must provide for the exercise of national security, rescue, or NASA priority missions.

2. The government has made a major investment in the STS and the terms and conditions must appropriately recognize the investment and must contain methods by which the Government gains as each party shares appropriately in the risks associated with operations.

3. The private sector proposer would be making a major investment in extra STS fleet capacity and should have the potential for an appropriate profit over the lifetime of the investment. However, this appropriate return-on-investment must also not add to the price-burden for Shuttle customers so that they seek alternate launches and eventually drive up the price to both Government and private users due to significant decreases in launch rates.

4. The prime requirement of the national STS is a safe and effective operation, and the private sector proposers would have to agree to an Orbiter configuration which is safe and will meet overall STS fleet requirements.

5. An agreement between the Government and a private sector proposer for the purchase of an Orbiter or other capital investment in STS cannot be exclusive, without competition, or must maintain an option for other interested parties to purchase an Orbiter or make a capital investment on a similar or equal basis.

6. Any final such agreement between the Government and a private sector proposer must be a public agreement, which is demonstrably in the Government's interest as well as meeting the legitimate needs of the proposer.

NASA has not, as yet, identified the need for legislation to authorize the privatization or commercialization of the Space Transportation System.

Commercial Use of Space Policy

Question 7: The NASA Commercial Uuse of Space Policy and the White House Space Initiative include a broad array of initiatives including legal, regulatory and economic stimuli. When can this Committee expect to see a space commercialization "economic incentives" package submitted by the White House? Aren't these economic stimuli critical if these space commercialization initiatives are to compete with other high tech initiatives?

What initiatives are being pursued within NASA to facilitate purchases of commercial space products and services? What steps are being taken to encourage commercial development of support hardware for space-related activities?

What role did your Office have, if any, in ensuring the inclusion of "commercial incentives" in the forthcoming RFP for the Mars Geoscience Climatology Orbiter? Will this RFP provide commercial incentives?

Do Federal procurement laws impede NASA's acquisition of commercially developed hardware? What amendments to existing law would facilitate NASA commercial procurement activities? What commercially developed hardware or services are NASA contemplating procuring?

Answer 7: The Cabinet Council on Commerce and Trade Commercial Space Working Group is responsibe for the implementation of the National Commercial Space Policy. A NASA official serves as Vice-Chairman of this Working Group. Any forthcoming package of commercial space "economic incentives" would be based on actions taken by this Working Group. The enactment of such economic incentives would stimulate private sector investment in space and enhance the attractiveness of commercial space investments vis a vis other high technology initiatives.

NASA may agree, subject to laws governing Federal procurement, to purchase a commercial space venture's products or services if NASA has a need for them and if the private entity has significant capital at risk above that covered by the NASA purchase. Before agreeing to the purchases, NASA will issue a public notice to determine whether other investors are interested in developing similar products. NASA efforts to help any firm interested in investing in space-related commercial ventures will alsways be guided by our obligations to assure that our actions are fair to all concerned. In order to induce capital investment in space-related commercial ventures, NASA has signed a number of agreements which have directly served to stimulate or otherwise enhance the commercial development of support hardware such as upper stages, free-flying platforms for lease, or furnaces.

The RFP for the Mars Geoscience Climatology Orbiter will consider the inclusion of "commercial incentives".

NASA anticipates that procurement laws will enhance, rather than impede, the opportunities for privately financed commercial organizations to compete with established aerospace corporations in NASA hardware procurements. The Office of Commercial Programs is in the process of identifying any changes to existing procurement laws that may facilitate NASA commercial procurement activities. The only privately financed, commercially developed hardware that has been offered in competition for a NASA procurement is the Orbital Science Corporation's Transfer Orbit Stage coupled with an Apogee Manuevering Stage (AMS) bid in response to an RFP for an upper stage for the Tracking Data Relay Satellite System mission. A similar bid of the TOs coupled with an Apogee Manuevering Stage (AMS) is expected in response to an RFP for the upper stage of the Mars Geoscience Climatology Observer (MGCO) mission.

Joint Endeavor Agreements

Question 8: Recently, NASA has entered into a series of Joint Endeavor Agreements (JEA), principally with major aerospace firms. Is this trend indicative of the fact that only large corporations have the resources and staying power to pursue space commercialization R&D activities? What is the current status of the Microgravity Research Association JEA? Are there any time constraints on a JEA -- use it within such and such period of time or it's negated? Has NASA been able to meet its policy objective of approving JEAs within 6 months?

JEA's represent the principal method of Federal support for space commercialization R&D. What is the value of the JEA to a firm, and does it give one firm a competitive advantage vis-a-vis another firm? Are the technical, financial and managerial abilities of a firm considered before a JEA is agreed upon? Are there any restrictions on foreign participation or foreign financial support in a JEA?

Answer 8: JEA's with major aerospace firms should not be considered a trend. Of the seven major commercial agreements signed to date, three have been with small start-up firms. Currently, there are several small firms interested in engaging in agreements with NASA that appear to be capable of generating the technical and financial resources necessary to successfully perform under the terms of the contemplated agreements.

Microgravity Research Associates represents that it is on schedule in terms of its technical progress and its procuring of financing. MRA is interested in broadening the scope of its current JEA with NASA.

Typically, a reasonable maximum period of duration or fixed termination date is built into the provision of a JEA. However, that which NASA provides to a private entity under a JEA is allocated over a period of time, as mutually agreed, so that it is possible to monitor the private entity's performance prior to subsequent allocation.

It appears that some agreements can be worked out in less than six months. Others are inherently more complex and contain particularly significant implications for NASA policy and precedent and accordingly, will take longer. As such, six months should be an average negotiating time.

A JEA with NASA can significantly mitigate technical and financial risk to a private entity on a space-related capital investment project. To the extent that exclusivity is provided to the firm under the JEA, a significant competitive advantage can result.

A firm's technical capabilities are closely scrutinized at the NASA Field Centers. The financial and managerial abilities of a firm are natural parts of a business plan that sometimes is requested by NASA for other than well known firms.

NASA, as a matter of policy, does not engage in JEAs with foreign entities or domestic entities with significant foreign interest where the benefit of the commercial agreement would flow to the foreign company.

Government Obstacles to Commercial Use of Space

Question 9: A recent Heritage Foundation Report entitled "Government Obstacles to the Commercial Use of Space" is especially critical of NASA. For the record, would you please comment on the criticisms levied in this report, especially the accusation that NASA has attempted to dissuade its contractors from marketing competing satellite launch systems.

Answer 9: NASA takes exception to to the fundamental premise of the Heritage Foundation report: that NASA, through the operation of the Space Transportation System, is serving as a barrier to the commercial development of space. Also, it should be made quite clear that NASA has never attempted to dissuade any contractor from marketing a "competing satellite launch system" (i.e., an Expendable Launch Vehicle (ELV)).

Advisory Council Task Force

Question 10: NASA has an Advisory Council Task Force on the Commercial Use of Space. For the record, will you please list the members of this Council and indicate how your Office interfaces with this group? Does this Council represent all potential commercial users of space? Why is NASA so wedded to the idea that the private sector represents "commercial users" and not "commercial suppliers."

Answer 10: Members on the NASA Advisory Council Task Force on the Commercial Use of Space are as follows:

Dr. Thomas A. Vanderslice (Chairman)
Mr. Marvin A. Asnes
Hon. Ralph Becker
Mr. George B. Farnsworth
Mr. William Hambrecht
Mr. S. Allen Heininger

Dr. Glenn F. Kiplinger
Dr. Lester Krogh
Ms. Florence R. Skelly
Mr. Alva O. Way

This Task Force was designed to represent a cross-section of foreseeable potential non-aerospace users of space. They act as a combination evaluation and advisory council to the NASA Administration and, through the Administrator, to the Office of Commercial Programs. NASA recognizes that the private sector consists of both commercial users and commercial suppliers. Commercial Users represent the market segment with the greater potential for development but they must be informed about the benefits of space whereas the commercial suppliers are quite sophisticated about aerospace and therefore need less intense attention.

Commercial Payloads

Question 11: A recent edition of Aviation Week reported that NASA would be required to off-load 3 commercial payloads from the FY 1986 shuttle manifest and that NASA was considering launch of these payloads on Government ELV's. Is there any validity to this article, and what are the factors involved in this decision? Was any effort made to off-load these payloads to a commercial ELV firm instead of government ELV's?

Answer 11: As part of its normal contingency planning, NASA evaluated the use of available government ELV's for launching three Shuttle payloads. These vehicles are available because they were purchased for such a purpose during the transition period from ELV to Shuttle launches. The evaluation concluded use of ELVs was not necessary since the payloads could be accomodated within the Shuttle manifest. Also, among the reasons use of ELVs was not adopted was the reluctance of some of the customers to revert their payloads back to ELV compatibility now that they had made the change to the Shuttle.

There was no effort to off-load these payloads to a commercial ELV firm instead of government ELV's. At the present time, there are no U.S. commercially developed ELV's capable of flying these payloads; U.S. government developed ELV's, which some firms hope to privatize, are capable of flying them. However, it is our understanding that spacecraft owners are hesitant about signing contracts for these new ELV ventures without assurance of the continued existence of the new venture.

Question 12: In action in the House Science and Technology Subcommittee on Space Science and Applications last week, your proposed budget request for FY 1986 of $30 million was cut by $10 million. This cut was the result of concerns as to whether or not your Office could efficiently spend the $30 million and whether or not industry was willing to commit to the program.

What would be the effect of this reduction, if any, on your proposed level of activity in FY 1986?

What initiatives would be deferred if your FY 1986 funding was limited to $20 million?

Does your Office have the ability to efficiently use $30 million? And, is industry ready to commit?

Couldn't the Committee get a better return on its investment by funneling additional monies into the already operational Microgravity Research Program?

Answer 12: The effect of the proposed reduction will be to cut back on nascent programs designed to expand the data base required to stimulate the commercial development of space. Funding for the Centers for the Commercial Development of Space will be cut by several millions of dollars. Other cuts may cause specific program slow-down or the elimination of activities to stimulate private sector research.

The Office of Commercial Programs requested $30 million based on NASA Field Center requests associated with their private sector contacts. We have on file letters of industry commitment in many areas and we are in the process of funding them. As the program matures and the private sector becomes aware of commercial potential of space, there will be extensive industry interest requiring the commitment of NASA funds.

The Microgravity Research Program is not oriented toward commercial application although there is obvious benefit to a potential commercial user.

Space Station Advocacy Group

Question 13: A recent article in Space Business News is headlined "Space Station Marketers Line Up." The article then goes on to discuss NASA's contracts with two marketing firms that are to promote Space Station users. Why should there be a separate

Commercial Advocacy Group in the Space Station Office? Can't your Office interact and approach potential users of the Space Station or any other NASA program? Why should the Committee fund this duplication?

Answer 13: The primary responsibility of the Space Station's Commercial Advocacy Group is to ensure that the commercial user requirements are adequately considered specifically in establishing the Space Station's mission requirements while the4 Office of Commercial Programs has the overall agency responsibility for establishing policy on the commercial application of NASA research and development. A representative of the Office of Commercial Programs is a member of this group. While it is accurate that interactions with the industrial community may be initiated through the Space Station Program Office as well as through the Office of Commercial Programs, the authority to negotiate Joint Endeavor Agreements resides with the Office of Commercial Programs.

Profit Sharing

Question 14: Two recent developments have attracted a lot of attention in the trade press. They are the proposed profit-sharing arrangement for a free launch of a mobile communications satellite service and a deferred payment plan for the launch of commercial space hardware. Could you please inform the Committee of your role in each of these activities? Do these plans represent a new way of doing business at NASA? What led the agency to propose these policy options?

Answer 14: The profit-sharing arrangement and the deferred payment plan are options which NASA is evaluating to determine their effect and consequences. NASA is considering new options as a way to both benefit the taxpayer and stimulate the commercial use of space.

Stimulating Commercial Interests

Question 15: A fact sheet concerning the Office of Commercial Programs FY1986 indicates that your program will support the commercial development of space in the following areas:

- Centers for the Commercial Development of Space
- Increased Availability of NASA Facilities and Equipment
- Stimulating NASA Research with Commercial Potential
- Stimulating Private Sector Research With Commercial Potential

In describing these activities, there is a great deal of discussion of the Office of Commercial Programs supporting "basic research with commercial potential," "awarding grants that do not require peer review," "funding innovative non-aerospace commercial use of space," and of course Centers for the Commercial Development of Space.

a. In reading this fact sheet, is it correct to assume that NASA intends to fund a series of grant activities? Is this necessary to stimulate commercial interest in space?

b. Could NASA do more to stimulate commercial interest in space by providing more flight opportunities and great access to NASA facilities and equipment?

c. What inputs from industry or other commercial interests influence NASA to take this approach to stimulate commercial interest in space activities?

Answer 15: The only grant program contemplated by the Office of Commercial Programs is the Centers for the Commercial Development of Space. Proposals will be evaluated by a group of peers including substantial industry participation. These Centers were recommended by a Task Group as being a viable mechanism for encourging commercial development of space.

NASA is endeavoring to provide as much access to the Shuttle (and other facilities) as reasonably possible under the philosophy that the private sector will use the facility (e.g. Shuttle) more as they become familiar with their capabilities.

NASA has been working with industry for years in areas related to commercial space products. As we have received information through our Field Centers, NASA Headquarters Program Offices, the White House/Industry Working Group, and the NASA Advisory Council Task Force on the Commercial Use of Space, NASA has been exposed to a representative cross-section of industry inputs. We have also funded private sector studies that result in recommendations for action.

Senator **Gorton**. Ms. Dorn.

Ms. **Dorn**. Mr. Chairman, I would like to briefly discuss three of the commercial space initiatives which the Department of Transportation supports. My not mentioning others does not mean we are not supportive. However, the ones I would like to highlight have to do with supporting increased business activity in space, infant industries and increased opportunities for experimentation.

The second commercial space initiative has to do with maximizing the benefits inherent in the shuttle program. And the third, encouraging the private sector expendable launch vehicle industry.

In each of these three instances, success has been linked to full cost recovery, sometimes appropriately, sometimes inappropriately. The Department is supportive of all three, and we believe that they are not mutually exclusive goals. It is not a win-lose situation, Although it is often portrayed as such.

But I think we need to further discuss, as I know we will today, the ramifications of a full cost recovery policy on those objectives.

With respect to supporting increased businesses in space, that is precisely why we have more than one pricing policy, if you will. The commercialization policy which is issued by NASA in fact has a separate policy for infant industries, a policy in which they can offer such things as joint endeavor agreements, and other types of free flights and pricing incentives.

It is clear that full cost recovery pricing applies only to mature, fully commercial ventures. In the second instance, when we are talking about maximizing benefits which are inherent in the shuttle program, I think the full cost recovery policy assures that we in fact are going to have an effective use of the shuttle.

Across-the-board space transportation subsidies can tend to encourage a less-than-marginal use of a limited national resource. We feel it is very important to focus on research and development and new ventures in space, that that is to the benefit of the entire space program, to our leadership in space, when it is measured in really significant terms.

The third issue has to do with encouraging private-sector ELV's. That is probably the one that has gotten the most attention with respect to what is alleged to be a tradeoff with other kinds of policies. We do not feel in any way that it is a tradeoff. We do believe that full cost recovery allows the private sector only a fair opportunity to compete for a part of the market and take advantage of the capability they have to be a thriving private enterprise.

The customer indeed wants a choice, and that is indicated by the very aggressive competition that Arianspace has offered, because it is clear that customers do want more than one way to get to space. Our industry is clearly ready, willing, and able to do that, and they have been doing it for a number of years.

If I could just go back for a moment to talk about each of these separately, with respect to the commercial use of space, we expect and certainly hope for space-related investments to grow quickly in future years, creating many new jobs and greater prosperity for all Americans.

Space-based technology research is critical to such endeavors. For this reason the Government provides separate incentive pricing, as I mentioned, which is outside the full cost recovery pricing mechanism. We heartily support NASA's efforts to stimulate and support private investment in the commercial use of space through joint endeavors and other provisions of NASA's commercial space policy as I mentioned earlier.

It makes good economic sense to continue Government assistance designed to encourage those R&D initiatives, and we believe wholeheartedly in that; but business decisions cannot and should not be made on the expectation that the U.S. Government will provide financial support in perpetuity, especially when we have a limited national resource.

Indiscriminate transportation subsidies across the board, without consideration on a case-by-case basis, will necessarily eat into the basic science and R&D efforts that are critical to the Nation's space leadership, which is perhaps the most true measurement of leadership in space.

It is not the number of payloads that can be put on orbit, but rather the kinds of things that only the shuttle can do: Research and development, space science applications, the retrieval of payloads. No one else in the world can do these as well as the shuttle, and that is the true measure.

I fear that we get lost in the arguments of how many things we launch and how many times we fly after a certain level and what we put up there. I think that is a misplaced priority. Of course, such subsidies will seriously impede the development of private sector launch options, the expendable launch vehicle industry being one, as I mentioned.

With respect to commercial ELV's, as space becomes an ever more attractive setting for creative enterprise, our space transportation options must expand to fulfill increasing customer demand. The President has sought a more robust space-launch capability, and in fact we can achieve that with the breadth and depth that we have in space transportation just as the breadth and depth we have in other transportation sectors throughout the country, whether it is air, land, or sea.

It is the private sector, indeed, which historically in this country has been able to bring the cost of transportation down.

Competition in fact supports this, and we think it is no detriment to the shuttle to have that kind of competition for this limited share of the shuttle market. It is good for the space program, it is good for private industry, and we think it is a very important mark of America's leadership in space.

We believe that we can create an environment in which a viable, responsive, and innovative domestic ELV industry can develop. I think it is very risky to underestimate the kinds of commitments that the private sector can make to innovation when they know that there is a profit to be made and that there is a market out there for which, if they were given an opportunity to fairly compete, they could do so effectively.

In addition, we believe that the expendable launch vehicle industry is an essential hedge against unanticipated increases in demand or limitations in shuttle capacity at no direct cost to the taxpayer. We feel this is extremely important because of the shuttle's new demands, like the strategic defense initiative, the space station, and hopefully a number of new business ventures in space.

It may well be that the government is put at risk in the 1990's for not having adequate capacity. Why should the commercial and foreign payloads go to the foreign competition when we have a domestic ELV industry that is waiting and ready to capitalize on those opportunities?

It is clear that the commercial launch industry cannot become viable unless full cost recovery is established for the shuttle. Our goal is not to set an artificially high price, nor should it be to set an artificially low price, or to preclude the shuttle from competing for foreign and commercial payloads.

We seek, rather, full cost recovery pricing based on standard Government practice to provide full reimbursement for services rendered to foreign and commercial customers. When the Government sets prices for services which it offers in competition with the private sector, however, extra care must be taken to ensure that full costs are recovered so as not to distort the true utility to the market of those services.

The administration has not yet reached a decision as to the appropriate level for post-1988 pricing other than its commitment to full cost recovery, nor has it identified the range of prices that would reflect full cost recovery. We believe that commercial and foreign demand for launch services provides ample opportunity for the shuttle, a domestic commercial ELV industry, and Ariane to compete in the marketplace.

Mr. Chairman, we certainly recognize that this is a complicated issue, that it has often and unfortunately been laced with emotional issues and misperceptions. We look forward to the opportunity today to discuss with you and to work with you to ensure the success of each of the goals we have outlined. Each of us separately, and I think together, agree on the goals of the U.S. Government in space. We believe that we can indeed achieve the promise that a space-based economy holds for the U.S. Government and for America.

Thank you very much.

[The statement follows:]

STATEMENT OF JENNIFER L. DORN, DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION DEPARTMENT OF TRANSPORTATION

In May 1983, the President announced basic space launch policy goals for the United States. Those goals were to ensure a flexible and robust U.S. launch posture to maintain space transportation leadership, to optimize the management and operation of the Shuttle program, to exploit the unique attributes of the Shuttle, and to encourage the development of commercial launch operations by the private sector of the United States.

This Committee's support of these goals has played an important part in providing for the success of the Nation's space program. As you know, the Department of Transportation, and Secretary Dole in particular, share your enthusiasm for these commercial space initiatives. Today, in my testimony, I would like to focus on three of those: supporting increased commercial activities in space; maximizing the benefits inherent in the Shuttle program; and encouraging a private sector expendable launch vehicle [ELV] industry. The success of these initiatives has been linked to the Government's policy to recover the full cost of Shuttle services and capabilities provided to commercial and foreign users. As you know, the President has directed that the Shuttle recover full costs of services provided to foreign and commercial customers. This was the original intent of the initial plans for Shuttle pricing and would be consistent with comparable practices across the Government. It is our view that such full cost recovery allows for the effective implementation of U.S. space goals.

COMMERCIAL USE OF SPACE

It is well recognized that private firms now have the wherewithal to explore activities in space, that only a few years ago were barely imaginable. We expect space-related investments to grow quickly in future years, creating many new jobs and greater prosperity for all Americans. Space-based technology research is critical to such endeavors. For this reason, the U.S. Government provides separate incentive pricing, not subject to full cost recovery, as a means of encouraging such technology research.

NASA invests significant resources in support of such endeavors. We heartily support NASA's efforts to stimulate and support private investment in the commercial use of space—through Joint Endeavor Agreements and other provisions of NASA's Commercial Space Policy. We believe that it is in this initiative, in particular, that the partinership of government and private industry can make essential contributions to the successful commercialization of space.

Consistent with the Administration's policy, it makes good economic sense to continue Government assistance designed to encourage R&D initiatives. This assistance should no longer be provided once these endeavors become commercial. Business decisions should not be made on the expectation that Government will provide financial support indefinitely, nor should the taxpayers be expected to support businesses in this manner.

Perhaps more importantly, there are good reasons why the Government should not subsidize commercial space projects: First, transportation subsidies will necessarily eat into the basic science and R&D efforts critical to this Nation's leadership in space. Secondly, such subsidies will seriously impede the development of private sector launch options and the availability of the flexible and robust launch capability upon which an aggressive space program must be founded.

THE SHUTTLE PROGRAM

Perhaps the central element of America's space program is the Government's primary launch system, the Shuttle. The most technologically advanced and successful manned launch system available in the world today, the Shuttle is vital to our programs for advancing the state of scientific knowledge, pushing the limits of technology, launching interplanetary missions, and developing new industries. It affords new and wholly unique opportunities to do on-orbit experimentation and research, as well as provide a test-bed for proving the commercial viability of manufacturing materials in space. It serves important military requirements and will play a fundamental role in the construction and servicing of the space station. Its unique capabilities form the foundation of United States leadership in space. Full cost recovery for commercial and foreign users will not detract in any way from the pivotal role of the Shuttle program in U.S. space policy. Rather, full cost pricing, in keeping with time-honored principles of sound program management, will serve to establish an enduring basis for the full exploitation of the Shuttle's special capabilities, with the assurance of price stability and predictability for future customers.

COMMERCIAL ELV'S

As space becomes an ever more attractive setting for creative enterprise, our space transportation options must expand to fulfill increasing customer demand. As noted in his decision to encourage the development of a private sector ELV industry, the President recognized that, such an alternative, in particular, would "add to the general economic vitality of the United States and provide the United States with a more robust space launch capability."

In keeping with that goal and in response to direction by both the President and the Congress, the Department of Transportation has been directed to create an environment in which a viable responsive, and innovative domestic ELV industry can develop.

It is clear that expendable launch vehicles represent a national asset whose production lines and operational facilities should be maintained. They are essential as a means of providing assured access to space and as an important complement to the Shuttle launch capability. They are an essential hedge against unanticipated increases in demand or limitations in Shuttle capacity, at no direct cost to the taxpayer.

The commercial launch industry cannot become viable unless full cost recovery is established for the Shuttle. Our goal is not to set an artificially high Shuttle price or to preclude the Shuttle from competing for foreign and commercial payloads. We seek full cost recovery pricing based on standard government practice to provide full reimbursement for services rendered to foreign and commercial customers. When the Government sets prices for services which it offers in competition with the private sector, however, extra care must be taken to ensure that full costs are recovered so as not to distort the true utility to the market of these services. The Administration has not yet reached a decision as to the appropriate level for post-1988 pricing, nor has it identified the range of prices that would reflect full cost recovery.

We believe that commercial and foreign demand for launch services provides ample opportunity for the Shuttle, a domestic commercial ELV industry and Ariane to compete in the marketplace. In addition, there is a real possibility that Government and Shuttle-unique needs will expand-particularly with the demands placed on the Shuttle program by the space station, national security, and emerging commercial manufacturing. If this occurs, Shuttle capacity will be inadequate—at any price—to handle the needs of those commercial and foreign customers whose activities do not require manned missions. Without a private sector launch capability to provide for such contingencies, we stand to lose even greater ground to foreign competition. If a full cost recovery Shuttle price is not implemented, this private sector transportation option will simply not develop. The impact of such a decision will be felt in decades to come as new developments and demands make it clear that an ELV industrial base would be an important national asset.

Together, the private sector and the Government can work to maintain this Nation's leadership in space by providing a full spectrum of launch services to meet the diverse requirements of an expanding market. This committee will play an important role in determining the national strategies by which we meet this challenge. We look forward to working with you in an effort to ensure the success of each of the Nation's goals in the space program and to bring to fruition the promise that a space-based economy holds.

Senator GORTON. Thank you.

Senator Riegle has a conflict this morning, so I will ask him now to make any statement he wishes and to ask questions of these first three witnesses.

Senator RIEGLE. Thank you very much, Senator Gorton. I appreciate that. It is a conflict that we share in that the Banking Committee also went into session at 9 o'clock this morning on the nomination of Martha Sieger to the Federal Reserve Board, and that is not only a matter of some controversy, but she is a nominee from my home State, so I have some particular requirement to be there.

I will have to go back in just a moment. So, I appreciate your courtesy in allowing me to speak now.

I just want to say to you, Mr. Chairman, at the outset how much I welcome the chance to work with you this year on these issues and all other issues before the subcomittee.

The hearing today does cover a number of issues that are of critical importance to the future direction and success of our civilian space program. I find myself somewhat taken aback that we are facing this issue, since less than 30 years ago when our civilian space program began commercialization was rarely if ever discussed outside of science fiction circles.

The age of true commercialization of space is indeed upon us and the United States is at the forefront of this development. I think we must be very careful since the decisions that we make in the next few years will chart the course of commercialization activities well into the next century.

Therefore, I think we must make great efforts to maintain and enhance our competitive lead and recognize that competition will arise from many different nations.

Mr. Chairman, I am committed to the goal of commercializing our space effort. There is no substitute for the marketplace to help drive technological developments and to create demand for space-related products that no one has even conceived of today.

At the same time, however, I think it is key that we maintain a stable level of funding for NASA activities. which support scientific and conceptual development which lead to successful applications.

So, I look forward to studying with care the submissions that will be made by all of the witnesses today and to have a chance to discuss with them now and in the future these issues. I think we are going to be able to make some headway here and look forward to doing so.

I am sorry to have to excuse myself to go back to the Banking Committee.

Senator GORTON. Would you like to ask questions?

Senator RIEGLE. No; I will submit my questions for the record. I have a number of questions that I do want to have you respond to, but I think in the interests of time I will have you do that in writing.

Ms. DORN. Fine. Thank you, Senator.

Senator GORTON. Thank you, Senator Riegle.

Dr. Hanushek, are there historic precedents for selling government assets or services at prices which reflect reflect only marginal cost recovery.

Dr. HANUSHEK. Mr. Chairman, I think there is historical precedent for selling government services at almost any price you can choose.

We have considered the basis of prices at which the government sells services. Indeed, they range from full-cost recovery, or at least an attempt at full-cost recovery in such activities as uranium enrichment for example, to market prices in areas in which a complete commercial market exists, for instance, timber sales or sales of oil out of U.S. petroleum reserves. By the way, in those cases where a competitive market exists, we believe that government prices probably come very close to marginal cost prices.

In other areas in which the government sells excess power or water from the Bonneville Power Authority or irrigation water, I think the prices are very close to marginal cost pricing, although very seldom does anybody state that this is——

Senator GORTON. They do not articulate it in that fashion in other words.

Dr. HANUSHEK. That is correct. So, I think that there are a number of instances in which the prices look very much like marginal cost prices. If you ask us to certify that, we would say it was in the range.

Senator GORTON. What about the air traffic control system? Do you have any familiarity with its inception and prices charged for its services.

Dr. HANUSHEK. My understanding is that overall we try to recover the full cost of providing many of the airport services, but there are a number at——

Senator GORTON. Is that true at the beginning?

Dr. HANUSHEK. I am not sure of the exact historical basis. We do have some experts on air traffic traffic control costs and pricing at CBO.

Senator GORTON. Stand up and identify yourself.

Mr. Mudge. My name is Dick Mudge Chief of The Public Investment Units at the Congressional Budget Office. In the very beginning, there was no real link between user fees and costs of the air traffic control services. I am not sure whether it could be termed marginal or average cost price. Since 1970, it has been based on average cost pricing.

Dr. Hanushek. It is also obvious that there are a number of cross subsidies that go on in the air traffic business, so that while that is the overall goal, certain users in fact pay much less than the average cost of their services and others pay somewhat more.

Senator Gorton. Ms. Dorn, are you familiar with the analysis Dr. Hanushek has made, using phrases like shortrun marginal cost, longrun marginal cost, average full operational cost, et cetera?

Ms. Dorn. Are you asking whether I am an economist? I did not mean that in an offensive manner. Yes, sir; I am familiar with the general categories.

Senator Gorton. When you talk about cost recovery, which of these definitions of cost recovery are you referring to?

Ms. Dorn. If I could respond, first of all, by talking about why we do not believe that marginal pricing is an appropriate level of pricing for this type of activity. First of all, it is clear that the shuttle has been scaled to meet commercial business and therefore, in our view, commercial business should pay a pro rata share of the fixed cost base in order to adequately reimburse the Government.

Senator Gorton. Let us go to the fixed cost base. Is that the highest fixed cost bases, Dr. Hanushek talks about? Is that what he calls average full cost or average full cost less development, or full operational cost?

Ms. Dorn. Fine. If you want to talk about what, in my personal view, would come closest to the formula or the components that would be a standard Government definition, I could tell you that the full cost, less development, would approach what we consider to be a more standard definition.

That is based on things like OMB circulars, guiding principles, GAO, as well as NASA, and its full cost recovery objectives for the shuttle initially, as well as how it prices expendable launch vehicles.

Senator Gorton. What impact do you think that will have on shuttle load capacity?

Ms. Dorn. Sir, I believe that the shuttle's unique kind of attributes will always have—there will always be a market for its services. It depends how you want to define your goals. If your definition of efficiency and effectiveness is to fill up the shuttle, no matter how you fill it up, and fly it as many times as you can, then marginal cost recovery would be certainly appropriate.

However, if your goal is to do something more than that, if you want to achieve the maximum benefit to the Nation, then full cost recovery is not only desirable, but it is imperative. So, I guess we sometimes get lost in the measurement of success.

Senator Gorton. We certainly do. But you have to have some kind of attitude toward what that pricing policy will mean with respect to the utilization of the space shuttle. If we do, in fact, accept that definition and set it as a goal, do you have a view, as you have arrived at that, of how much utilization of the space shuttle there will be?

I take it by implication, it will not be 24 full loads a year. What will it be?

Ms. **Dorn**. First of all, Mr. Chairman, I guess we would respectfully differ with NASA in its projection of 24 flights a year being accomplished in 1988.

The second point is that the NASA mission model, even at 24 flights a year, projects two to four flights—that would be for commercial availability. Certainly, if you allow the private sector to compete, some number of those flights, but at the maximum, four flights, could be captured by a domestic ELV industry.

Senator Gorton. What you are saying, you are in favor of this policy, even though it would result in no commercial use of the shuttle.

Ms. **Dorn**. I do not think that will happen, Mr. Chairman. There are certainly commercial businesses which are shuttle-dependent, as opposed to telecommunications satellites to which this full cost recovery policy would apply.

Senator **Gorton**. I will amend my question. You will be in favor of this policy even though it means there is no commercial use of the shuttle other than that kind of commercial use which could not possibly use a competitor?

Ms. **Dorn**. No, sir; I do not believe that would happen. I think when you have a level playing field, that in both the opportunity to compete, and you cannot guarantee the success of one or the other entrant into the market.

Senator **Gorton**. Mr. Gillam, I will let you comment.

Mr **Gillam**. Mr. Chairman, I am not sure I remember all of the questions that you asked.

Senator **Gorton**. Maybe I will just let you react to Ms. Dorn.

Mr. **Gillam**. I would rather not do that.

We, at NASA, believe based on our current experience, as Mr. Beggs testified before the House, that, at the current pricing policy of $71 million in 1982 economics, we are currently splitting the market 50/50 with Arianespace. We believe that raising the shuttle to significantly higher pricing levels would decrease the shuttle's share of the commercial and foreign market and it would reduce the amount of other commercial business going into the shuttle. Whether that business goes to Arianespace or the ELV's is something that remain to be seen.

Senator **Gorton**. You do not know? You do not have any estimates?

Mr. **Gillam**. Our estimate is that Arianespace is currently underbidding the shuttle in our most recent competitions by about $5 million per mission. There has also been a U.S. an ELV entity participating in those competitions, and Arianespace underbid that U.S. commercial entity as well.

Senator **Gorton**. That is really what I was directing my question to. To the extent that that the pricing policy causes you to lose business, do you think you would be losing it to Arianespace or to commercial ELV's?

Mr. **Gillam**. Based on what has happened in the last 14 months, Mr. Chairman, we think we would lose it to Arianespace and that the Arianespace's market share would go up. Undoubtedly, it is possible that some of the business would go to U.S. ELV's.

On the other hand, an extremely high shuttle price, we believe, would have an adverse impact on the national goals as outlined in the National Space Policy. Those goals are: Leadership in space, maintaining our position of leadership there; it would have an adverse impact on the goal of increasing private sector investment and involvement in our space activities because we have a relatively binary policy in NASA, either an authority is research or it is commerical. We have a program of Joint Endeanor Agreements [JEA's] for research activities.

The minute a customer or user becomes commercial—we do not have a policy for infant industries—the minute he becomes commercial, he is charged the commercial and foreign price. So that a high price would not only affect the business opportunities associated with that, but the high price would also deter his entering into a research effort in the first place.

We also have another goal of obtaining the economic benefits of space and a high price would have an adverse impact on the entire commercial program, thereby impacting our ability to successfully or satisfactorily meet that goal.

In general, of the six major goals that the Nation has announced in its National Space Policy, all save one which is associated with national security, would be adversely impacted by extremely high commercial and foreign shuttle prices.

Senator Gorton. Dr. Hanushek, that is a good point to move back to you. It sounds to me like Ms. Dorn has taken of your five definitions of cost, average full cost less developed would be $106 million per flight.

What goals do you think that would enhance as you set them out in your analysis, and what goals would it inhibit?

Dr. Hanushek. Although, we have not done the complete cost analysis of private ELV's, at that price I doubt that private ELV's could be very competitive and would not be able to enter the launch market.

Senator Gorton. Even if the cost recovery were average full cost less development?

Dr. Hanushek. That is correct, at a little over $100 million in 1982 dollars. There is some question about the impact on the budget and efficiency because we do not know how Arianespace would respond to a price like that. Arianspace is the one current viable competitor, and they view their business as trying to get a share of this market, so they would probably try to underprice a shuttle price of about $10 million. They would raise prices above what they are currently charging, but underprice the higher shuttle price.

So if that is the case, the most likely situation would be that the market share would not change that much between NASA and Arianespace, but simply that prices would rise for private users. At these higher prices, some commercial activities would no longer be viable uses of space.

Senator Gorton. They simply would not use anyone?

Dr. Hanushek. That is right. At that price, people would drop out along the way. So you would have less commercial use of space with that price as compared to either the $87 million price that NASA has talked about or some long-run marginal cost price.

Senator **Gorton**. In all probability, NASA would not fill this commercial space under those circumstances?

Dr. **Hanushek**. I think that is probably true, and I think that as best we can tell, NASA would probably have fewer annual flights than the 24 it now estimates. Thus, if you go back and ex-post recalculate the average costs, they would be actually above what we have estimated on the basis of 24 annual flights.

Senator **Gorton**. Mr. Gillam, Ms. Dorn does not believe you will be flying 24 flights a year. What do you think about that?

Mr. **Gillam**. Just a couple of comments, Mr. Chairman. One is that we have been planning and working toward 24 flights a year for a good deal of time. We are establishing a capability to fly 24 times a year and unless I am mistaken, we were directed by the President just a few weeks ago to use 24 flights a year as our planned capability.

Senator **Gorton**. Ms. Dorn?

Ms. **Dorn**. I wonder if I could comment briefly about what objectives we fulfill at various pricing levels.

Clearly, I would agree with Eric that there is not a single price that supports all of the objectives. That is why we in effect have a multitiered pricing policy even now, and would have even more so in 1988 and beyond.

We have one level of pricing as an incentive for infant industries. The Government has gone the extra yard. We have another level for Government users and how they reimburse NASA. And finally, we have one for the commercial sector. It seems to me that we——

Senator **Gorton**. Should we have a fourth for foreign users?

Ms. **Dorn**. Commercial and foreign would be under the category under the——

Senator **Gorton**. Should we have a fourth for foreign users that would be different from the commercial?

Ms. **Dorn**. Under the present policy of the administration, fiscal year 1988 and beyond, commercial and foreign users would be in the same category.

Senator **Gorton**. I understand the present policy. That is not what I asked.

Ms. **Dorn**. No, sir. I believe that the commercial and foreign payload policy is appropriate as a category. It would seem to me that we need to comment about a couple of things.

First of all, what Arianespace is planning to do. We do not expect that Arianespace will get a greater portion of the market than it already has. They have approximately 50 percent in 1984. We expect that if the Ariane IV produces as they project it to produce, that in fact in the long-term, they may well capture 40–50 percent of the market. No more than that, for a number of reasons, one of which: Is that the customer wants an option. He wants to have competition and that is why Arianespace got going in the first place. If it were not the case, Arianespace would not have entered the market.

With respect to the recent competition that our domestic ELV's have had with Arianespace, it is clear that one of the primary reasons that they were unable to capture that particular payload or group of payloads was because of the lack of confidence by the customer community in the long-term stability of a domestic ELV industry which is forced to compete with the Government. That had a significant effect on whether or not the domestic ELV industry would be competitive.

If we can achieve a level playing field with our international competitors, then clearly we are going to be able to compete as a domestic ELV industry. That is what we are seeking to do in the section 301 petition and I think it can come about.

It is very clear from the analysis we have done at the Department of Transportation as well as other agencies and in informal discussions with Arianespace, they plan to increase the price because they are pricing in reaction to NASA's shuttle as is the price leader. And as the shuttle price increases in accord with full cost recovery, we believe Arianespace's price will rise comparably.

Senator GORTON. If we cut the price in half, Arianespace would cut its present price in half?

Ms. DORN. I could not comment about what would happen. It seems to me that Arianespace is likely to price its service at whatever level they need and a little widget below. And that is what they are doing right now.

There would be no need to capture a greater portion of the market from an economic or business sense from Arianespace is perspective, and so we expect that they would raise the price.

Certainly if the shuttle's price decreased then Arianespace in its attempt to retain its share of the market, would likely decrease its price as well.

Senator GORTON. I think I have gone on too long.

Senator Rockefeller, would you like to ask some questions?

Senator ROCKEFELLER. I have not been in this field before, and this is my first committee meeting, as the chairman knows. So my approach is perhaps less specific and more generic.

What strikes me for the moment is some reasonable to substantial degree of uncertainty as to future use. And I understand quite well that the 1989 to 1991 period is fundamentally looking at 24 flights per year. And that sounds reasonable because we are that kind of a country, until you start looking at some of the things that have been happening.

Where this was triggered was when you, Ms. Dorn, slipped in the word Star Wars, and as soon as you said that, if it was you, I said, I wonder if that is trying to create the impression of business for the shuttle because it is entirely possible that another President might move away from SDI.

It is true, I believe, that the Air Force has signed an ELV contract, has it not, with Martin Marietta. They are going to do a variety of things to existing Titan ICBM's, and in fact there are potentially 62 more ELV's in existence, of a Federal nature, this year than there were last year.

And then I go back to the 24 missions a year, which kind of makes me feel secure. That is solid, predictable, and the kind of thing one budgets for. And then you wonder how many were there this year, this past year? And I am not sure if it reached double digits. And then how many are scheduled perhaps for this coming year? Well, that would be 11, would it not? But now, has there not already been slippage with the current schedule? I know Senator Garn is on the ground and not in the air.

So I guess my question is: In that setting a shuttle price, obviously it is important to see shuttle activity, provided activity is of either national security use, of national commercial use, of international commercial use, of international cooperation use, or for whatever other justifiable cause. But where there is cost involved, then it seems to me there has to be some degree of predictability.

Now it is my understanding that when the Air Force signed their CELV contract with Martin Marietta, which will not appear before us this morning, that he made the Air Force promise to use one-third of the shuttle flights for a 10-year period, 1988–98. Is that correct?

Ms. Dorn. That is my understanding. If you mean by "he," the President?

Senator Rockefeller. Yes, the President.

Ms. Dorn. Yes, that is correct.

Senator Rockefeller. So that that is one way of filling up the shuttle manifest, so to speak.

Ms. Dorn. One-third of the available flights.

Senator Rockefeller. But it probably would not have been the way the Air Force would have chosen, had they not received the order from the Commander in Chief. Or am I wrong?

Ms. Dorn. It is my clear understanding, Senator, that the Department of Defense had every intention of using perhaps even more than one-third of the available flights. This, however, made it in concrete that there was a commitment from the Department of Defense to perform at least one-third of the missions of available flights that would be DOD missions.

Senator Rockefeller. Let me just ask this question. If, after 1988, there is not a strategic defense initiative by whatever reason, if that descends as a national priority for political reasons or for whatever reasons, what do the three of you really feel is the consistency factor in the future of this program with respect to the so-called sound and substantial use factor?

Because if you are not convincing, then it seems to me that maybe the House is right; they better keep their price low because we may not be getting very much business. And maybe the lesson from this so far, as applies to a young technology granted, the lesson in this so far is that the ELV market is not nearly what we thought it was going to be. Now I will shut up.

Ms. Dorn. If I could respond to that, Senator. If in fact, the strategic defense initiative does not come to pass as a result of congressional disapproval or for whatever reason, we certainly have other kinds of requirements that are anticipated in terms of the space station and new commercial ventures in space. And, of course, we cannot forget the all-important role of the shuttle in performing research and development space science applications activities.

It is my understanding that individuals from the National Academy of Sciences who have watched this closely have some degree of concern that, even now, we are postponing space science missions as a result of not being able to fly on the shuttle and because of the priority of commercial ventures.

In addition, it is difficult to project unexpected contingencies with respect to any operational problems that the shuttle may have, or delays. When you discuss the Titan Program, I think it is important again to emphasize that that meets the Department of Defense need for assured access to space, and it has nothing to do with the commercial part of the market which is the part of the market and the only part of the market which the domestic ELV industry seeks to capture.

We believe the ELV industry provides a hedge against uncertainty. It is very difficult to make projections in the outyears, as you aptly point out, about what Government demand will be, what the commercial demand will be. And we think that, at no cost to the Government, we have an option here for a national resource that has been taxpayer supported for a number of years, that it would be a shame to waste, and that we may, in fact, need.

Senator ROCKEFELLER. For what?

Ms. DORN. For what?

Senator ROCKEFELLER. Yes.

Ms. DORN. For commercial applications.

Senator ROCKEFELLER. Then where is the energy from the commercial sector?

Ms. DORN. The energy, as we have projected it, and we have looked at an analysis that has also been looked at by other agencies in the Government, we expect that there will be approximately 20 telecommunications, or commercially available is the proper term, satellites in the market beginning in the year 1989 to 1994.

So that is part of the driver for the shuttle, only a small part. It is the exclusive driver for unmanned vehicles such as domestic ELV's and Arianespace.

Senator ROCKEFELLER. OK.

Do you other gentlemen want to address that?

Mr. GILLAM. Yes, I would like to comment on what you are asking. NASA's position with respect to the shuttle is a matter of record. The shuttle is a new system. It is the first time we have ever had such a system and we have flown it 15 times to date. We believe the more often you fly the system, the more you learn about it, and the more you gain from the flights. In addition, Ms. Dorn mentioned that the scientific community is complaining about the fact that they have not had the opportunity to fly their payloads. I might add that the scientific payloads that we are talking about generally are secondary payloads, and they need a shuttle flight to be conducted for other reasons in order to be able to be accommodated. So we want to fly the shuttle as often as we can to accommodate these requirements; but, we have no intention of flying a shuttle mission simply for secondary payloads, because that is an expensive way to go about doing business. So, we want to fly the shuttle as much as we can. We want to learn as much as we can from the system, and we want to do something useful while we are up there.

On a typical commercial mission where we are launching commercial communication satellites, if we have three aboard, those three satellites are launched in the first 2 days of the mission, so we have 3 more days up there to learn about the system, to conduct research, to conduct other scientific activities that have both commercial and scientific potential. So on a mission where we are strictly flying communications satellites, we are learning about the system, we are gaining research knowledge and conduct many other activities. We do not just go up, drop out the communications satellites, and then come back.

Finally, the advent of the space station should reduce the workload of the shuttle. Once the space station is here, the shuttle will have the opportunity to revert to more of a role of strictly a transportation system to and from the station. Therefore, the on-orbit requirements that are placed upon the space shuttle will be substantially diminished when the space shuttle arrives rather than being increased.

Mr. **Hanushek**. I just would add that I think you have hit on an absolutely key part of the whole discussion—that is, the uncertainties are really very large in 1989 or 1991. One alternative might be to set a more flexibile pricing policy for the out years and wait to gather more information about both the costs and the demands for the shuttle before announcing a 1991 price.

There are advantages in announcing a price long in advance, because many of the uses take a lot of time to plan, to put together, and to construct a satellite or what have you. At the same time, we do not have to set a price for that whole period or a rigid price. We can consider some flexibility. In fact, NASA, I think, is going to request some flexibility in their pricing, and I think that is entirely appropriate.

Senator **Rockefeller**. Thank you.

Senator **Gorton**. Thank you all very much. This does not end the list of questions that the chairman has, and Senator Riegle has questions as well. We will submit more questions to you in writing, but we thank you for now.

We do need to get on to our last group representing the private sector, which is Dr. Scherer, Mr. Samuels, Mr. Hood, Mr. Lippy, Mr. Ferguson, and Mr. Savoca.

Mr. **Gillam**. Thank you, Mr. Chairman.

Senator **Gorton**. Thank you all for coming. We were listening with great patience to the earlier witnesses. Simply because we have terrible time constraints, you are each going to be limited to a 5-minute opening statement at the end of which a red light will go on, a buzzer will go off and a hook comes down from the ceiling.

But your written statements, which have been submitted, will be included in the record. So if you will deal with your salient points, we will appreciate it.

We will start with Dr. Scherer.

STATEMENTS OF DR. LEE R. SCHERER, PROGRAM DIRECTOR, COMMERCIAL SPACE PROGRAM, GENERAL DYNAMICS; JAMES P. SAMUELS, SHEARSON LEHMAN/AMERICAN EXPRESS; ROBERT H. HOOD, JR., VICE PRESIDENT AND DEPUTY GENERAL MANAGER, MCDONNELL DOUGLAS ASTRONAUTICS CO.; DAVID W. LIPPY, PRESIDENT, CENTER FOR SPACE POLICY, INC.; BRUCE W. FERGUSON, ORBITAL SCIENCES CORP.; AND ANTONIO SAVOCA, PRESIDENT, TRANSPACE CARRIERS, INC.

Mr. SCHERER. Mr. Chairman, and Mr. Rockefeller, we commend you and members of your committee for your continuing support and interest in space commercialization. I want to address one aspect, the future of an important national asset: the expendable launch vehicle. For the record, Convair has now launched 268 space missions with our ELV's, including 2 in the last 2 weeks.

In response to your broad question, it is important to differentiate between two categories of space commercialization which frequently are lumped together but for which different policies may be required.

The first are those uses made possible by being in space where one can produce products of possible great commercial value such as pharmaceuticals and crystals. The second is transportation. Included under this heading are the ELV's such as Delta and our Atlas/Centaur.

The first category—materials processing—has the greatest potential. This may lead to industries of high economic value. Major barriers—cost of transportation and risk faced by investors.

To surmount these barriers we recommend multitiered pricing for shuttle transportation. The NASA joint ventures policy allows extensive research at no transportation costs. When larger development quantities are planned, some marginal cost could be charged. Only when a commercial product intended to make a profit is to be produced should full transportation cost be considered. For the second barrier, heavy R&D risks, special tax incentives should be structured.

In the transportation category the United States made a conscious decision to phase out our ELV programs because we believed the shuttle could handle all traffic. Ironically, this decision started international competition, because the European Community thought otherwise and developed their own ELV, Ariane. Time has proven their decision to be sound, and Ariane is now a formidable competitor.

In 1983, the President encouraged our industry to commercialize ELV's, which led to our current dilemma of our Government competing with our private sector.

Our ELV industry is well positioned to move into the commercial market now. We can maintain the know-how for producing and launching these vehicles—a national resource cultivated and improved over many years. Once stopped, it is unlikely that production would ever restart to try to compete with foreign launch vehicle competition.

ELV's can only provide satellite transportation. The space shuttle, a magnificent technological development, can do many more things. Because of the shuttle, we are able to produce new materials in space, repair, retrieve, and rescue, and give a new flexibility to our national security community. If our ELV's exist to compete against Ariane, the shuttle can concentrate on unique missions that push the edge of science and technology. This is the strength of NASA that has produced such magnificent achievements.

The shuttle pricing policy will determine whether or not there are American ELV's.

There are certain questions which should be addressed. First, considering our budget deficit, should there be price supports for the commercial communications satellites using the shuttle?

Second, how fast will new programs develop that must use the shuttle, such as test flights for the space station, SDI requirements, and the materials processing which holds such great promise. These types of flights may fully occupy the shuttle capability after the next several years. If there are no American ELV's, who will challenge the Ariane monopoly?

Third, if there was ever a technical reason to temporarily ground our fleet of orbiters, would it not be desirable for the United States to still have the ELV's available for that contingency?

Fourth, NASA has recently indicated that everything possible will be done to hold the schedule for commercial satellite launches, including delaying Government payloads if necessary. Is this a proper priority for our outstanding R&D organization?

Our recommendation is that we heed the words of the President as he encouraged ELV commercialization: "We are going to bring into play America's greatest asset, the vitality of our free enterprise system." We do not wish to see one American space launch system receive a favored status over another. Our request is merely that we be allowed to compete on an equitable basis.

Mr. Chairman, I appreciate the opportunity of being allowed to present these views, and I will be pleased to respond to questions.

[The statement follows:]

STATEMENT OF LEE R. SCHERER, DIRECTOR, COMMERCIAL SPACE, CONVAIR DIVISION, GENERAL DYNAMICS CORPORATION

Mr. Chairman and Members of the Subcommittee:

It is a distinct honor to appear before this distinguished Committee as a representative of the Convair Division of General Dynamics Corporation to discuss the commercialization of space and, in particular, the viability and future of an important national asset - Expendable Launch Vehicles (ELV's).

I would like to commend Chairman Gorton and the other members of the Subcommittee for convening this hearing at this time. I believe that the subject matter with which we will deal today is not only of great importance to people associated with our space programs, but indeed to all Americans who share our pride in this nation's pre-eminence in space.

Convair has been involved in the United States space program since its inception. A few months prior to the Soviet Union's launch of Sputnik in 1957, Convair flew its first Atlas rocket. Our Atlas launches include such notable U.S. space programs as MERCURY, RANGER, MARINER, SCORE, OGO, TIROS, NOAA, NAVSTAR, and others. To date 480 Atlases have flown, 197 of which were for specific space launches.

In 1972 Convair flew this nation's first High Energy Upper Stage, Centaur. To date Centaur has flown on 62 Atlas/Centaur vehicles and 7 Titan/Centaur vehicles. Atlas/Centaur alone has launched about one-third of the communications satellites launched from the United States. Nearly all planetary and interplanetary missions of the United States as well as many scientific missions have been launched on either the Atlas or Centaur. These launches include such successful missions as SURVEYOR, PIONEER, VIKING, AND VOYAGER.

Convair is particularly proud of its association with the Space Shuttle program. We designed and built the mid fuselage for the Space Shuttle Orbiters. Currently we are modifying the Centaur for use as a High Energy Upper Stage to launch NASA's planetary missions, GALILEO and ULYSSES, from the Space Shuttle bay. The Centaur-in-Shuttle program will serve not only NASA missions but also priority national security missions requiring Centaur's high performance.

The Space Shuttle was conceived as a reusable vehicle that would transport crews and payloads to low earth orbit. In addition to the Shuttle's role as an important national asset, it provides a unique capability by virtue of its very large payload capacity, on-orbit versatility, and recovery capability. The presence of man increases the Shuttle's flexibility for mission implementation. Capabilities for extra-vehicular activity, problem solving, and on-orbit repair capability are significantly increased and have already been beautifully demonstrated. Only a unique vehicle such as the Shuttle could make possible the prospect of convenient Space Station logistics support, retrieval and return to earth of low altitude spacecraft, commercially produced products or valuable test samples which have been left in orbit.

In response to the broad questions asked by the Subcommittee, it is important to differentiate between two categories of space commercialization which frequently are lumped together under this title and for which different policies may be required. The first category can be simply termed materials processing. This includes those uses made possible by being in space where one can manufacture products of possible great commercial value, such as pharmaceuticals and crystals. The second category is transportation. Under this heading are the Government-developed ELV's such as Delta and Atlas/Centaur which our Government has encouraged the private sector to operate on a commercial basis and upper stages to operate out of the Shuttle to place payloads into other orbits.

It is the first category--materials processing--that has the greatest potential for the future. At stake is our leadership role in scientific research. This may lead to industries of great economic value. Further, it is an area with tremendous opportunity for international peaceful cooperation in space--which encourages peaceful cooperation on earth. The major barriers and issues here are the cost of transportation and of insurance, and the risks plus long wait for return on investment faced by corporations and private investors.

Actions or initiatives needed to realize the potential benefits are those necessary to surmount the barriers above. A multi-tiered pricing structure for Shuttle transportation is one idea that has been espoused. The Joint Eneavors with NASA allow extensive research at basically no transportation costs. When larger quantities are to be produced taking a greater percentage of the payload bay, then perhaps some marginal price could be charged. When a fully commercial product intended to make a profit is to be produced, then the full transportation costs might be assessed. An exception could be made if there is an overriding public interest such as might exist with some major medical advancement. Other initiatives that can be considered should address the fact that corporations and investors must assume heavy R&D risks. Attractive tax incentives would be an example.

The remainder of my statement addresses the commercial transportation category. As a corollary to the development of the Space Shuttle, the U.S. Government made a conscious decision to phase down and eventually terminate the Expendable Launch Vehicle programs with the expectation that the Shuttle would be able to handle all available traffic at a cost and schedule to satisfy all potential customers. It was believed there would be no further need for ELV's by the early 1980's.

Ironically our decision to purposely terminate American ELV's is that we created an international space launch competition. The European Space Agency, desiring independence from U.S. launch vehicles and skeptical about our Shuttle schedule rationale, proceeded with the development of their own ELV, Ariane. Time has proven that the Europeans' analysis which led to the development of Ariane was sound--indeed there was still a need for ELV launches. The Ariane has emerged today as a formidable competitor with a well-sized booster system, substantial financial backing from European banks and governments, and aggressive marketing.

We were pleased by the issuance last year of an Administration policy designed to encourage the commercialization of U.S. ELV's, as well as the designation of the Department of Transportation to encourage and facilitate commercial ELV activities by the private sector. The affirmative action taken by this Committee last year in its passage of legislation to provide for commercialization of ELV's has greatly encouraged our efforts to date.

The U.S. ELV industry is well positioned to move into the commercial market at this time. If our industry is viable we will maintain the knowhow for producing and launching ELV's, a national resource cultivated and constantly improved over many years. Once stopped, the tooling dismantled, and the skills disbanded, it is highly unlikely that production could ever restart in such a way that it would be competitive with the ongoing and developing foreign launch vehicle competition from not only Europe but also Japan, China, and Russia.

When commercial communication satellite launch requirements are considered in conjunction with the planned DoD. NASA, and other U.S. Government missions, we believe that the launch demand exceeds the current capability of the Space Shuttle. NASA has manifested payloads to fill the projected high launch rates the Orbiter fleet may be capable of attaining, but this rate projects a sharply upward learning curve which exceeds the NASA experience to date. If the high launch rate is not attained there will be an overflow of commercial payloads to ELV's. And the U.S. should be able to compete for such launches.

The Space Shuttle, a magnificent technological development, is best suited for the many types of missions which ELV's cannot accomplish. Because of the Space Shuttle we are able to design varieties of payloads which we never before have flown. We are able to produce new materials in space, repair, retrieve and rescue (as has been so beautifully demonstrated already), and to give our national security community a new flexibility. If the American ELV's exist to compete against the Ariane and other developing foreign ELV's, the Shuttle can concentrate on unique missions that push the edge of science and technology. This is the strength of NASA that has produced such magnificent achievements directly and spinoffs whose values are legendary.

There are those who believe that if the Shuttle price is increased all future commercial satellites will select Ariane. Whether the Ariane price would increase commensurate with the Shuttle is not known. However, European spokesmen have stated that the production and launch facilities are planned for a limited number of launches per year. This number is about the maximum number of comparable vehicles that the United States has ever launched in one year. The current Ariane manifest is near that limit. Accommodating all of the commercial satellites will require a substantial investment in additional facilities.

The basic question is - should there be price supports for commercial satellites using Shuttle, or should the Shuttle compete in the free market with American ELV's. The answer will determine the viability of ELV's. There are certain questions which must be carefully considered by those making the decisions.

- Considering the national priority of reducing current budget deficits, to what extent, if any, should the United States support the difference between the cost of the Space Shuttle and the launch price for commercial satellite customers? If there is a difference, to what extent is it reasonable to support one national launch system over another in terms of that Government assistance?

- How fast will programs develop that require extensive use of the Shuttle and for which there is no alternative? Among these are: precursor test flights for the Space

Station in which systems and subsystems are tested in orbit; Space Defense Initiative requirements; possible joint rescue missions with the USSR; materials processing which holds such great promise. These types of flights may fully occupy the Shuttle capability after the next several years. If there are no American ELV's, who will challenge the Ariane monopoly?

o If, in the unfortunate event that there was ever a technical reason to temporarily ground our fleet of Space Shuttle Orbiters, would it not be desirable for the United States to still have ELV's available for that contingency?

o Since cost per flight is so dependent on launch rate, if the stated Administration policy of full cost recovery is followed, one must make a judgment on the number of Shuttle flights per year that reasonably can be expected. Will NASA be able to meet its ambitious forecast schedule, or will the schedule improvement be more in line with past experience?

o Recently, NASA spokesmen have indicated that everything possible would be done to hold the schedule for commercial satellite launches, including delaying Government payloads, if necessary. Given the subject being considered by this committee today, is that reversal of NASA's original priority sensible? Would it not be better for NASA to hold a higher priority for Government payloads?

The answers to these questions require either conjecture or careful thought. However, we believe it is clearly not in the best interests of our country to see the magnificent potential of the Space Shuttle eroded and endangered by a price war with a foreign competitor to attract commercial satellite customers. Our recommendation is that we heed the words of the President who last year encouraged ELV commercialization saying, "So, we're going to bring into play America's greatest asset; the vitality of our free enterprise system."

We do not wish to see one American space launch system receive a "favored status" over another. Our request is merely that we be able to compete on an equitable basis. Our national priority should be to preserve the Space Shuttle for its unique missions and use ELV's for commercial satellite transportation and as a Shuttle back-up when necessary. Together they provide a more total reliable and comprehensive space launch system for this country.

Mr. Chairman, I appreciate the opportunity that you have provided to present these views. I will be pleased to respond to any questions you might have. Thank you.

Senator **Gorton**. Thank you, Dr. Scherer.

Mr. Samuels.

Mr. **Samuels**. Thank you. Mr. Chairman, Senator Rockefeller, it is a distinct honor to appear before this committee as a representative of Shearson Lehman Bros. to discuss the commercialization of space. I greatly appreciate this opportunity.

The large potential for commercial space ventures has attracted the attention of financiers who are continuously seeking new business opportunities. Unfortunately, further study of this area has uncovered several obstacles.

First, space projects are far more capital intensive than conventional Earth-based businesses. Typical venture proposals require approximately $5 million. In space projects, $5 million is usually insignificant.

Second, the time required for investors to recoup their investments and profit from them is almost twice as long as normal ventures. Conventional investments have 3- to 5-year paybacks, while space ventures might not generate positive returns for 8 to 10 years.

Third, space-related projects are perceived to be extremely risky, and in many instances proposals are dependent upon innovative or unproven technologies.

Fourth, space projects are generally an unfamiliar field for many investors, and individual investors require significant education before they can be comfortable with the necessarily large investments.

With the exception of communications satellites, investors have had little experience with space ventures. As a result, investors are unable to draw upon the store of knowledge to compare these investment opportunities with more traditional ones.

Finally, as compensation for these factors, investors have demanded extraordinarily high returns for their capital and have looked to the Government for help in offsetting these risks. These several problems have made raising capital for the space projects extremely difficult and have generally precluded the use of more conventional sources of capital; namely, equity and debt.

As a result, entrepreneurs have had to rely upon internally generated funds and the Government for more innovative financing techniques such as R&D partnerships. While R&D partnerships and governmental aid can be utilized by most organizations, only the larger, well-established companies can depend upon internally generated funds for projects of this magnitude.

R&D partnerships, despite being complex and expensive, can improve the attractiveness of high-risk ventures through tax advantages that permit investors to deduct much of their investment against ordinary income and to treat future returns as long-term capital gains.

Additionally, the partnership structure enables partners to pass through losses to individual investors, limits the liability of limited partners to their actual investment, and permits the corporations sponsoring the effort to retain control without diluting its equity or adversely affecting its balance sheet.

Another source of capital, directly or indirectly, is the Government. Tax incentives like R&D partnerships and tax credits, free-

or below-cost use of Government facilities, and joint-endeavor agreements with NASA have been instrumental in enabling commercial space projects to progress.

Aside from the monetary or quasi-monetary contributions, the Government has been viewed as a way or reducing the risk associated with space projects. Restricting markets, noncompete agreements, and guarantees are ways in which the Government can raise the probability of success per venture and protect an investor's money.

The primary risk, though, in all legislatively created benefits and incentives is that they can be eliminated or meaningfully changed with the stroke of a pen. So, we have an attractive opportunity in front of us, yet before we can all enjoy the fruits of the industry, each of the several participants must make a contribution.

The investment community must educate itself with regard to space projects. Entrepreneurs must develop sound business plans that incorporate all the facets of a venture far enough in advance so that complaints from potential investors can be recognized, addressed, and resolved.

Also, entrepreneurs must not press for overly restrictive agreements or pursue unnecessary litigation to preserve guarantees. These tactics will only delay the commercialization of space.

Finally, the delicate task of determining appropriate policy in a constantly changing environment can be quite difficult. Nevertheless, the participating governmental agencies must find suitable ways of encouraging commercial space ventures without disadvantaging projects already under way.

The shuttle is an excellent example of this type of situation. The final pricing decision on the shuttle could have a meaningful impact on investors who have already placed bets relying on a supposedly established set of guidelines. If Government-imposed rules are permitted to change in an unanticipated way, future investors will probably be more cautious with new projects that depend upon Government guarantees, and Government aid could lose its effectiveness in allaying investors' fears.

We do not mean to imply that an uneconomic project should be supported indefinitely. Ventures ultimately must pass the acid test of a free market. Unfortunately, endeavors to publicly finance commercial space-based businesses could depend upon the success of the initial projects, even though no logical link might exist between, for example, transportation elements and materials producing equipment in space. The failure of either project could create a very negative attitude in the investment community for all space-related proposals.

The desire to differentiate businesses in a given field is not a strong suit among investors, and an unsuccessful effort only a small segment of the industry can cause the entire industry to be painted with the broad brush of failure.

So, in our opinion, there is an incentive to be somewhat more supportive of projects currently underway than the underlying economics might warrant. However, new businesses like commercial space are constantly evolving and will require different supportive efforts over time. The delicate transition from the initial phases of a project to a more mature phase must be handled with extreme caution so that midstream rule changes do not lead to catastrophic results for investors.

Otherwise, if the initial commercial space ventures are legislated into failure, the commercial space industry will have even more difficulty in an already tough environment raising capital through traditional fund-raising mechanisms.

[The statement follows:]

Statement of
James P. Samuels
First Vice President, Shearson Lehman Brothers Inc.
March 14, 1985

Summary

Future endeavors to publicly finance commercial space-based business could depend upon the success of the initial projects. Also, plans for space ventures must be all-inclusive, able to stand on their own merits, must specifically address objections that investors will raise, and must be thought out far enough in advance so that potential problems can be recognized, addressed early, and overcome. Finally, NASA, the White House, and Congress must be consistent in their support of commercial space ventures, and rules or guidelines cannot be changed in midstream so as to disadvantage projects already under way. Accomplishing these objectives will not ensure that commercial space businesses will be successful. However, a failure to adequately address these issues will certainly, in our opinion, greatly increase the difficulty of obtaining favorable results.

Introduction

The interest of many investors has been piqued by the conceptual appeal of space and by the large dollar amounts involved. Putting the size of the market in perspective, the Center for Space Policy, an organization specializing in evaluation of commercial and industrial opportunities in space, has forecast that by the year 2000 gross annual revenues for specific commercial space ventures could approach $50-$60 billion.

Government Support

The White House, NASA, and Congress have been strongly supportive of space commercialization.

NASA has created a position for commercial programs within the Office of Space Flight, has generated a comprehensive space commercialization policy, and has begun to enter into joint endeavor agreements (with Fairchild Industries for example), to promote private participation in commercial space ventures. It has also set aside $50 million in its fiscal 1985 budget for advanced development programs.

The Department of Transportation has created the Office of Commercial Space Transportation to help private industry coordinate the many governmental agencies that touch on space activities and to help eliminate or at least lessen the bureaucratic complexities that can exist among different governmental agencies.

Congress recently passed an act designed to promote economic growth and entrepreneurial activity through utilization of space, and to encourage the private sector to provide launch vehicles and associated launch services.

Public Law 98-52 provides for a comprehensive civilian program of research and development to enhance U.S. capabilities for remote sensing from space and the application and utilization of such capabilities.

Some of these examples are related to specific space activities, but the general tone in Washington appears to be quite supportive of entrepreneurial efforts in space — especially in light of the new White House policy that complements the NASA effort by providing tax relief and other incentives to spur investment in commercial space operations.

Roadblocks

Unfortunately, having projections for huge markets and support from all the important administrative branches of the government is not sufficient, in our opinion, to ensure that adequate capital will be directed toward this industry.

Investors are going to apply the same sets of standards and look for the same elements that must be present in any attractive financial proposal, and this creates a major problem with regard to space investments.

r one thing, space projects are capital-intensive; and consequently, most proposals do not have access to venture capitalists whose average involvement is about $5 million. In space projects, $5 million is usually insignificant. This phenomenon forces entrepreneurs to rely on nontraditional sources of early capital, or to structure projects differently. To date most companies have dealt with this obstacle by being large themselves and/or by allying themselves with Fortune 500-type companies. McDonnell Douglas teaming with Johnson & Johnson and Orbital Sciences teaming with Martin Marietta are examples of each.

Second, payback periods are long. Unlike conventional investments, space ventures might not generate positive returns before eight-to-10 years. This compares with the typical three- to five-year payback period for normal venture deals. Mathematically, the longer time horizons demand larger positive earnings streams once profitability is achieved if a project's internal rate of return is to be competitive.

Third, space projects are perceived to be extremely risky. Interestingly enough, though, the unknowns for space ventures are similar to those for new earth-based ventures. Will it work? Will it sell? What will it cost to build, and what exogenous factors are likely to adversely affect projections? Nevertheless, industry observers believe that these uncertainties are greater for space-related projects than those they are accustomed to dealing with.

Fourth, many projects that have been proposed rely upon innovative or unproven technologies. This phenomenon sharply heightens anxiety regarding questions like "Will it work?" and "Can we build it within our original cost limitations?"

Fifth, space projects represent an unfamiliar field for many investors. The excitement and conceptual appeal of space notwithstanding, institutional and individual investors require a significant amount of education before they can be comfortable with large investments. With the exception of communications satellites — which have been extremely successful from many perspectives — investors have had little experience with space ventures. As a result, investors are unable to draw on a store of knowledge to compare these investment opportunities with more traditional ones.

The sum of all these observations is that sensible investors will seek extraordinarily high returns as compensation for real and perceived risk factors. And this creates a chicken and egg problem. In order to reduce required rates of return, one must enjoy successful ventures. However, to demonstrate this favorable experience, one must have access to capital at affordable or economic rates to begin with.

Institutional Risk

Aside from these elements, another cause for concern in the investment community is the problem of institutional risk. Earlier we discussed the positive attitudes of the White House, NASA, and Congress toward commercial space projects. Unfortunately, the situation is not as clear as the covering verbiage would make it appear, and many important fundamental questions have yet to be resolved.

Although the White House has voiced its support for commercial space ventures and helped create departmental offices to facilitate space-related projects, the administration has also expressed its intention to lessen governmental regulation, is studying the possibilities for having governmental agencies turn certain services (like LANDSAT) over to commercial operation, and has created conflicts like the shuttle pricing issue currently being studied. Also arising is a military/civilian conflict that has yet to be resolved for businesses like LANDSAT and expendable launch vehicles.

This uncertainty with regard to government support certainly affects risk because the primary proposal for lessening the institutional risk that we have mentioned is to enlist the aid of the government. Examining some of the aid to date, one can appreciate how important government support can be. One of the more obvious forms of help has been subsidized shuttle launch rates. To date, users of shuttle services have been beneficiaries of a technology that they have enjoyed at substantial savings. Investment and development tax credits are additional forms of economic aid that can transform otherwise unattractive pro forma statements into financially viable business plans. Joint endeavor agreements are examples of how private industry and the government can mutually benefit from joint utilization of common facilities and skills unique to both parties. Finally, and this list is by no means exhaustive, the government can guarantee to purchase a product or service and restrict or bar competitive new entrants in either equipment or service markets.

The benefits in most examples are obvious, although some perceived benefits like tax credits can have the opposite effect of what was originally intended if businesses, for example, delay projects while awaiting a yet-to-be enacted tax benefit. Another drawback is that price incentives, like reduced shuttle launch rates, could compress launches into a shorter timetable than economic conditions alone would warrant. The primary risk, though, in all the legislatively created benefits and incentives is that they may vanish as quickly as they materialized with just the stroke of a pen. Thus, the economic feasibility of projects that are dependent on specific government support could be severely damaged. We believe that this institutional risk is a tremendously important element in space projects.

The space shuttle is an excellent example of a project largely affected by institutional risk. Many commercial space businesses are either dependent upon the availability of inexpensive space transportation or rely upon the shuttle as the only means of transportation. In the former category communications satellite owner/operators depend upon low-cost launch capability to remain competitive with ground-based communications media like microwave and fiber optics, where transmission costs are falling rapidly, not rising. In the latter category certain projects like electrophoresis and materials processing can be performed only on the shuttle. If communications satellites were offloaded to expendable launch vehicles would a sufficient volume of alternate missions be available to fill the shuttle manifest? Our research leads us to believe that a sufficient volume of offsetting missions does not exist, a situation that could jeopardize the continued availability of shuttle service. Such a happenstance could lead to the discontinuation of experiments that can be performed only on the shuttle. Thus, the philosphical questions of what costs must be recovered or whether the launch costs ought to be a specific number are almost irrelevant if one is truly interested in encouraging commercial space projects. Nevertheless, the final pricing decision on the shuttle could have a meaningful impact on investors who have already placed bets relying on a fixed set of circumstances. If government-imposed parameters are permitted to change, future investors will most likely be more cautious with new projects that depend upon government guaranties, and government guaranties could lose their effectiveness in mitigating institutional risk.

Space Projects Must Compete

In order to successfully compete in the financial markets for capital, space projects must be structured to overcome most of the objections that investors have identified. We wrote earlier about investors requiring high rates of return as compensation for, or to offset, the multitude of problems that apparently exist. This complaint can be satisfied by simultaneously targeting major markets and restricting competition. In addition, although many projects require large initial capital investments, subsequent operating expenses tend to be far smaller. Thus, projects can be shown to be immensely profitable after the initial years -- especially if government guarantees continue to restrict competition so that pricing can remain high.

So, by seeking large markets, in this case possibly $50-$60 billion, by taking advantage of the operating leverage inherent in such operations, and by utilizing governmental guarantees and supports, entrepreneurs can formulate projections for such operations that can realistically be quite appealing despite all the caveats outlined earlier.

Space Is Already Big Business

Space has been big business for many years. In fiscal 1984 the government spent more than $11 billion with outside contractors on space-related activity. Moreover, communications satellites have generated billions of dollars in construction, launch fees, and service revenues. The bulk of these efforts and expenditures has gone into communications and entertainment satellites, but much research and development work is under way in pharmaceuticals, gallium arsenide semiconductor processing, space-processed gases and metals, and remote sensing to name just a few.

Where has the money for these projects come from? Aside from tax incentives, free or below-cost use of government facilities, and joint efforts with NASA, most space work has been performed by relatively large companies and financed through internally generated funds. This phenomenon contrasts with the more conventional sources of capital, namely debt and equity, both of which are somewhat unsuitable for the early stages of space projects.

Financing Options

In order to raise straight equity in the public markets, a space-related business would have to demonstrate an internal rate of return of 50%-70%, which even under the favorable circumstances described earlier might be difficult to do. Debt could possibly be raised at prime plus three, but some collateral would be necessary that would preclude most service businesses from consideration and limit candidates for debt financing to those involving hard assets like transportation, advanced communications, or perhaps utilities.

These problems leave only special financing techniques, like R&D partnerships, as possible sources of capital. An R&D partnership generally contracts with an outside entity to perform research and development for a project. Similarly, some arrangement (normally in the form of an option) is reached with an outside party to arrange for the sale of the partnership's technology, which provides capital gains treatment of the project's income.

Because of the complexity of these arrangements and the corresponding requirement for excellent professional assistance in preparing the partnership offering, R&D partnership offerings have high transaction costs compared with most equity and debt offerings. Sales commissions, legal and accounting fees, and printing costs (which are currently not normally deductible for new partnerships) typically account for 10%-20% of the offering proceeds. The offerings themselves require six months to a year to structure and complete. R&D partnerships are also expensive in that they by definition involve high risk, for which investors demand a commensurate return. Projected aftertax internal rates of return for R&D partnerships typically range from 35% to 50% — less than sought for in an equity offering, but still quite high relative to more traditional investments.

Although an R&D partnership cannot eliminate all the difficulties surrounding commercial space projects, and has some objectionable features of its own, the device has many elements that make financing unfamiliar ventures more palatable to investors. One of the primary reasons for the popularity of R&D limited partnerships is the tax advantages offered in conjunction with the business goals of a project. Some of these advantages have been significantly lessened by the Tax Reduction Act of 1984 and the Tax Equity and Fiscal Responsibility Act of 1982, both of which seem to contradict the strong support generally provided by Congress and the White House to R&D limited partnerships. Nevertheless, the tax incentives remain sufficiently strong to be attractive. The two important tax advantages are: (1) the ability to deduct most of the investment against ordinary income; and (2) that future returns can be treated as long-term capital gains.

Aside from tax benefits, the partnership structure itself benefits the individual investor. First, partnerships, unlike corporations, can pass through deductions for R&D expenditures to the individual. Second, participation as a limited partner rather than as a general partner limits the exposure of the investor to the amount of his investment. Third, the corporation sponsoring the R&D limited partnership is able to retain management control of the project without necessarily diluting its equity or otherwise adversely affecting its balance sheet.

To date, the largest space-linked R&D limited partnership that has been completed was Orbital Sciences, and it might be helpful to examine why this effort was successful.

How Orbital Sciences Raised Capital

We believe that Orbital Sciences Corporation (OSC) was able to raise money through a limited partnership not solely because a portion of the risks was reduced through tax benefits -- although this feature helps considerably -- but also because the entire concept of the organization and its goals seems to be constructed to specifically address the objections that potential investors have raised with regard to space projects.

1. OSC has a reasonable business plan. The plan shows that OSC intends to have a positive cash flow not in the 1990s, but in this decade.

2. The principals in the management team, although young, have had experience in this specific field and have surrounded themselves with older, more experienced individuals.

3. Technological risk appears to be low, due primarily to use of "off-the-shelf" technology.

4. NASA has agreed that it will not directly fund development of alternative systems to transfer orbit stage (TOS) missions.

5. OSC has negotiated a fixed-cost incentive contract with Martin Marietta to develop the TOS with a maximum total price or cap so that development costs are not open-ended.

6. The number of scheduled launches of geosynchronous satellites shows a dramatic increase in the second half of the decade, which should create strong demand for the TOS missions.

In other words, it is difficult to discover a logical flaw in the OSC story -- especially when the end market is as conceptually appealing as space is.

This carefully crafted plan in itself will not ensure that OSC will be successful in meeting its own and investors' objectives. A large part of the success or failure of OSC and other space ventures will ultimately depend not on the largesse of the government, but on the underlying economics of the project and on the consistency with which government policies are administered.

New businesses like commercial space are constantly evolving and require different supportive efforts as circumstance warrant. At this particular stage of its development, we believe that commercial space projects will require special government consideration. We do not believe, for example, that the emerging commercial space industry can advance without noncompete agreements from NASA or by eliminating subsidized space shuttle launches while the French continue to subsidize theirs.

We do not know how some of these issues and conflicts will be resolved; however, we feel quite strongly that if the White House or NASA significantly changes the rules in midstream so that particular projects are disadvantaged or participants become severely handicapped, the commercial space industry will have an extremely difficult time raising capital through traditional mechanisms in the future.

Wall Street's Role in Space

This brings us to our last point. Wall Street has been quite clever over the years in developing innovative financing techniques. The problem for new industries, though, was that these creative approaches were usually developed to raise capital for known quantities.

In other words, Wall Street is conservative. Bankers, analysts and portfolio managers like to see a corporate history, a track record, or at least something familiar that can be evaluated and/or used as a standard.

So, even though dollar amounts for commercial space projects are sufficiently large to attract the attention of most bankers, response or follow-through with an actual underwriting has been almost nonexistent.

From my perspective, although there has been a lot of motion, Wall Street has been more of a fence sitter or observer. There are some exceptions. Shearson Lehman Brothers, in conjunction with the Center for Space Policy, has begun publishing a monthly report entitled "SPACE", which discusses commercial opportunities in this field. Response to this report has been gratifying, in that investors appear to be genuinely interested in commercial space ventures. However, most readers simply want to be kept informed about progress in this area and generally remain skeptical about the emergence of real investment opportunities.

We believe that Wall Street's job is to educate institutional investors regarding legitimate commercial opportunities in space so that this territory can become familiar ground, and to steer investors away from opportunists attempting to capitalize on the appeal of space.

Finally, private investor participation will, to a large degree, in our opinion, depend on the success or failure of early showcase ventures. These first efforts will be watched closely, and if they are successful, future efforts to raise capital will be facilitated. If they are not, raising capital for even unrelated space ventures could become more difficult.

Points to Ponder

This paper is not intended to be pessimistic. We believe wholeheartedly that many attractive commercial space opportunities exist and that additional ones will emerge. However, each ingredient in the recipe must make a contribution. The investment community must educate itself. Entrepreneurs must develop sound business plans that incorporate all facets of a venture far enough in advance so that the majority of complaints from potential investors can be recognized, addressed, and resolved. Also, entrepreneurs must not press for overly restrictive agreements or unnecessary litigation to preserve guarantees, nor should they adhere to an original plan when changed circumstances would otherwise warrant a different approach. These tactics will only delay the commercialization of space. Finally, the delicate task of determining appropriate policy in a constantly changing environment can be quite difficult, but the participating governmental agencies must find suitable ways of encouraging commercial space ventures without disadvantaging projects already under way.

Senator Gorton. Thank you.

Mr. Hood.

Mr. Hood. Thank you, Mr. Chairman, Mr. Rockefeller. Thank you for inviting me to speak.

I am Robert Hood of McDonnell Douglas Corp. I think it is clear to all of us that we are on the threshold of the opportunity to develop a significant new industry. There is no doubt in my mind that there is money to be made in space, and along the way we will revolutionize industries like the construction industry with extraordinarily versatile new building materials and we will make giant leaps in the development and production of medicines to treat cancer, diabetes, and heart disease which has plagued us for many generations. And yet, those rosy predictions do not depend on any of us in this room today, but rather on a sound and rational government policy concerning the commercialization of space.

The United States has launched more satellites, performed more difficult missions and manufactured more products in space than any other nation on Earth. The cornerstone of the success is the space shuttle and an affordable, dependable transportation system. That space shuttle system along with other complementary technologies such as new upper stages developed by many of those sitting here at this table, will become a symbol of a country's spaceborne supremacy.

But America's pre-eminence in space is being threatened, for the first time. The heavily subsidized European expendable launch vehicle, Ariane, recently has won competitions on several satellite launch contracts over the shuttle and PAM combination.

An additional threat comes from those who are advocating a change in the NASA pricing policy to higher prices for the space shuttle. They call for the shuttle to pay its own way, and they claim that the lessening in the shuttle subsidies will open the door for American launch vehicle companies to compete for new space dollars.

I sympathize with their position because McDonnell Douglas was in the expendable launch vehicle business for some 25 years, but I simply do not believe that by raising the price of the space shuttle we are going to enhance the expendable launch vehicle market. I feel that Ariane will undercut whatever expendable price comes about. We will then tend to delete the number of missions that the space shuttle will be capable of flying, and therefore I think ultimately increase the cost.

Now there is much more at stake here than just satellite launches. Space-borne manufacturing materials processing can take off like a rocket in this country in the next 5 years. A project like our own electrophoresis has little use for expendable launch vehicles like Ariane. We do not need one-way tickets up. We need a roundtrip ticket, something to get our raw materials up and to get our finished products back and to the marketplace.

We started out 8 years ago in developing this EOS project when the space shuttle price was at $31 million per flight. We identified 11 natural biological products as likely candidates for space-borne production. The recent increase to $71 million cut that list to six. The proposed increase to $87 brings that down to four, and some of those are marginal.

Mr. Chairman, members of this committee, there is no stronger supporter of the American space program than McDonnell Douglas Corporation. We have been involved in these commercial projects since 1972. This is actually McDonnell Douglas' fourth commercial space venture starting with the upgrading of the first stage of Delta in 1972, progressing to PAM later on in 1970, to EOS in the late 1970's, and to PAM-D2 in 1981.

We are one of the first to enter the microgravity arena, and we feel the heat of the wary stares from those corporations and other industries who are waiting to see if we can make money, and if we cannot, we think that sends the wrong signal to those Industries waiting in the wings to invest in commercial space products.

To herald the commercialization of space as a major national objective while increasing the cost of necessary transportation systems is a serious contradiction. To discourage the use of the space shuttle in the name of supporting private operation of some very old technology is not promising to space commercialization.

So I urge you, Mr. Chairman, in the strongest terms to provide the industry with the tools to lead our Nation toward the world of enterprise and hope.

Thank you very much.

[The statement follows:]

STATEMENT OF ROBERT H. HOOD, JR., VICE PRESIDENT AND DEPUTY GENERAL MANAGER, MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

Mr. Chairman, Members of the Committee: Thank you for inviting me to speak today on this very important issue of space commercialization. In a way, I feel that I am not only representing existing businesses, but also the myriad of businesses about to be born.

Current estimates indicate that total investments in space-related industries reached approximately $250 million in 1984, and spending is projected to top $1 billion by 1988. Why so much interest? Because there's gold in them thar orbits. Even conservative forecasters see annual revenues for space industries in the tens of billions of dollars by the year 2000.

Clearly, there is money to be made in space. And along the way, space-bound entrepreneurs will greatly enhance the world understanding and the free flow of information with telecommunications satellites. We will revolutionize industries like construction with extraordinarily versatile new building materials. And we will make giant leaps in the development and production of medicines to treat such maladies as cancer, diabetes and heart diesase which have plagued previous, earth-bound generations.

And yet, today, the realization of all these rosy predictions depends not on a handful of foresighted entrepreneurs, but rather on a sound and rational government policy concerning the commercialization of space. Right now, America is far and away the free world leader in space. We've launched more satellites, performed more difficult missions and manufactured more products in space than any other nation on earth.

The cornerstone to this success is the space shuttle—an affordable, dependable space transportation system. A number of new technologies have been developed especially to work with the shuttle . . . technologies like the McDonnell Douglas Payload Assist Module which boosts satellites from the space shuttle's cargo bay into geosynchronous orbit. Together with such complementary technologies, the shuttle has become the symbol of this country's spaceborne supremacy.

But America's pre-eminence in space is being threatened for the first time. The heavily subsidized European expendable launch vehicle, Ariane, recently has won competitions on several satellite launch contracts over the shuttle/PAM combination.

An additional threat comes, ironically, from those who believe they are helping America by demanding that NASA charge a higher price to its shuttle customers. In these budget-conscious days, they call for the shuttle to "pay its own way." They claim that a lessening in shuttle subsidies will open the door for American launch vehicle companies to compete for the new space megadollars.

But the bitter truth is that this simply would not work. Consider this scenario: The shuttle price goes up from the already high $71 million per dedicated flight to the proposed $87 million. American launch companies step in to vie for satellite launch business against the shuttle and Ariane. Customers that would have gone to the shuttle move to the private launch companies. But the Europeans woo customers from the Americans with ever lower subsidized prices. Unable to compete, the American companies are forced out of business. We would then be left with a shuttle that is more expensive than ever to maintain due to lack of satellite payloads.

In terms of this country's role as a leader in space commercialization, that's a sad story. Yet, many analysts agree that it would be inevitable given the current aggressive posture of the European launch industry.

But there's much more at stake here than satellite launches. With affordable transportation, space-borne manufacturing and materials processing could take off like a rocket in the next few years. Projects like the McDonnell Douglas Electrophoresis Operations in Space or EOS have little use for expendable launch vehicles like the Ariane. Such one-way tickets mean nothing to space-based manufacturers who are entirely dependent on a retrievable space vehicle to get their high-tech products back to earth—back to market.

EOS is now the shuttle's largest commercial activity. This McDonnell Douglas program has shown that certain life-saving pharmaceuticals can be made in space in larger quantity and with much greater purity than is possible on earth. At the 1980 shuttle price of $31 million per flight, we identified eleven natural biological products as likely candidates for space-borne production. The recent increase to $71 million cut that list to six. The proposed rate of $87 million brings us down to four, and some of these are marginal.

Mr. Chairman, Members of the Committee, there is no greater supporter of America's space program than the McDonnell Douglas Corporation. Our Payload Assist Module was the first commercially developed and marketed satellite booster. We've been involved in Electrophoresis Operations in Space for eight years and in manned space flight from the very beginning. So I find it somewhat disconcerting to admit that we have begun to re-evaluate our efforts in these new and exciting space ventures.

We are one of the first to enter this micro-gravity arena and we feel that the heat of wary stares from other corporations, other industries. They're waiting to see what we can make of this, and they're watching those rising shuttle prices bite into the profit projections on their spread sheets.

If this trend of shuttle price increases continues, America may find itself in the awkward and internationally embarrassing position of having the know-how, but not the will to fulfill our grand promises of wonder drugs and super materials.

To herald the commercialization of space as a major national objective while increasing the costs of the necessary transportation system is a tragic contradiction. To discourage the use of the space shuttle in the name of supporting the private operation of some very old technology is not promoting space commercialization. It is succumbing to the expedient. It threatens to choke off an historic movement in American business before it has time to blossom.

An so I urge you, in the strongest terms, to provide industry with the tools to lead our nation toward this world of enterprise and hope. You can lay the foundation for our next industrial revolution. For its promise, the future looks to you.

Thank you.

Senator GORTON. Thank you very much.

Mr. Lippy.

Mr. LIPPY. Mr. Chairman, Mr. Rockefeller, I am David W. Lippy, president of the Center for Space Policy, Inc, and we appreciate the opportunity to address the subcommittee concerning our views on shuttle pricing, space commercialization, and the proper role of the Federal Government.

Our latest market forecast is still underway, but our preliminary findings predict that by the year 2000 commercial space revenues will top $50 billion per year. As compared with our earlier projections of $65 billion, this represents about a 20-percent reduction.

The most significant change in our analysis has been a reduction in the potential of materials processing in space from roughly $40 billion to about $25 billion. This reevaluation is due to two changes in our methodology.

The first is the employment of more sophisticated market projection analysis techniques. The second and most significant factor has been a slip in our scenario of space station IOC from 1992 to 1994. Given the current stretch in the phase B program and the likelihood of other budgetary and program delays, we feel this is a more realistic estimate.

This delay has a significant impact, because our trends show that revenues begin to grow substantially in the outyears of the program. Hence, much of the growth anticipated in our earlier projections will now occur just after the turn of the century.

In order for this industry to develop efficiently, the government must set and achieve two objectives: One, to develop and broaden man's basic understanding of the environment of space; and two, to provide and maintain routine access to space at a reasonable cost. Both of these objectives are clearly in the best interests of the United States. Time and money spent on these objectives now will lay the groundwork for a very large new American industry.

A number of Government initiatives are necessary in the near future to lay this groundwork. In support of the first objective to broaden the research base, the Government must continue to support the development of basic research and technology development required for full commercial exploitation of space. The NASA Centers of Excellence Program is a beginning, but it is just a beginning.

In addition, the Government should continue to invest in the development of high-leverage generic infrastructure such as the shuttle and the space station, which in turn encourages private investment.

These are two aspects of the same objective of providing access to space. The first is that the space station is an essential element of all new space industries. In our studies, we have not found even one space-related industry that will not be significantly improved by the presence of a permanently manned space station.

Having built the space station, it may be tempting for the Government to step back and declare that it has done its share in the commercial development of space. At a time when the Federal budget deficit has become a critical problem, this action may seem especially appealing. On the contrary, this action would be harmfully shortsighted.

The shuttle program was never envisaged as an end in itself, but as the next logical step for developing the ability to use space on a routine basis. It is one critical component, but not the only one that we must develop.

The second and most immediate aspect of providing access to space is cost. On the question of shuttle pricing, the Center for Space Policy, Inc. supports the NASA position. From an historical perspective and on the implications to the long-run development of space, the shuttle is the bridge to profitable commercial operation for every commercial endeavor except the ELV industry.

A high shuttle price may be in the best interest of a very few firms. However, it is not in the long-term interest of private industry as a whole, the government, nor the citizens of the United States. Because of the importance of this issue, I will elaborate on our reasons for taking this position.

In the early 1980's, firms interested in commercial ELV's began their ventures with the assumption that, despite their higher price when compared to the shuttle, there would be a market nitch for them to fill. They forecast an insufficient launch supply in the aggregate, and they believed that some users would be willing to pay a premium for flexibility afforded by a dedicated launch.

Studies projected up to 50 commercial communications satellite launches per year. This market has not developed. In short, there was a miscalculation on the part of ELV manufacturers as to the size of the market. Faced with the declining market, the ELV manufacturers have asked for a change in the rules. They want shuttle prices to rise to a level where they can compete. They want communications satellites taken off the shuttle.

The net effect of this policy would be to harm the entire space industry in order to support a handful of companies providing launch services. The communications satellite market would be hurt immediately through higher launch costs. Launch costs already comprise as much as 50 percent of the total cost of a satellite system. Doubling that cost could result in consumers paying more for the services, or communications satellites could become economically unviable possibly negating demand all together.

Nascent commercial space industries, and especially the materials processing industry, would also be adversely affected. High space transportation cost is already a problem for this industry which is in its R&D stage. Whereas, the cost of launching a communications satellite can be credited against its 10-year revenue stream, a materials processing experiment lasts only as long as the duration of a shuttle flight. Hence, the cost must be absorbed quickly, and if no product is produced, there are no offsetting revenues.

The net effect of higher shuttle prices would be a reduction in the flight rate and a corresponding increase in the cost per flight, effectively precluding much of the R&D needed to launch the materials processing industry. Higher SPS prices would also hurt a broad number of companies that have invested millions of dollars to develop shuttle upper stages. Their investment is already much higher than the amount expended by ELV manufacturers.

Finally, the costs for Government missions would also rise. At a lower flight rate, we would loose the manifesting flexibility and therefore face higher costs to launch the Government payloads. Given the pressure on the Federal budget, the most likely impact of a rise in launch costs would be a decrease in the number of missions which NASA could fund.

On a closing note, CSP believes as a matter of national policy, tax reform must be considered not only with an eye toward the immediate problem of deficit reduction or improved equity-to-tax system, but it must also consider the long-term consequences to the capital investment and technology development process which are keeping the United States at the forefront of the world economy.

The budget cannot be balanced if U.S. technology leadership is allowed to shift abroad.

These are just a few of the issues we are facing today in the commercial space enterprise.

Thank you, Mr. Chairman, and members of the subcommittee for the opportunity to express our views here today.

[The statement follows:]

STATEMENT OF DAVID W. LIPPY, PRESIDENT, THE CENTER FOR SPACE POLICY, INC.

Mr. Chairman and distinguished members of the Subcommittee: I am David W. Lippy, President of the Center for Space Policy, Inc. CSP greatly appreciates the opportunity to address the subcommittee concerning our perspective on the commercialization of space—its potential, its pitfalls, and the proper role of the Federal Government in encouraging its development.

The Center for Space Policy, Inc., is a private consulting firm, based in Cambridge, Massachusetts. CSP is the largest and most diversified firm to specialize in the identification, evaluation and implementation of business opportunities in space. Our extensive contacts in industry, the financial community, and government have enabled us to develop what might be termed an "integrated perspective" on the development of space. Based upon this perspective, we would like to give you an industry overview, rather than the view of any particular segment. We believe that this is extremely important, for in our daily deliberations, we often tend to lose sight of the overall pattern, and too often focus on specifics of near-term issues. I would like to propose today that we view commercial space development with an eye not only on the future, but on our past experience as well. I would like to propose to you "guiding principles" by which specific federal initiatives and responsibilities may be judged—in short, a set of guideposts for the future.

I. THE POTENTIAL OF SPACE

The commercial development of space offers the United States and mankind enormous potential benefits. Our national investment in civilian space programs already has produced notable successes in the fields of meteorology and communications. The potential for further benefits is enormous and should not be brushed aside as a concept too nascent to be taken seriously. One only has to look back to 1950 and ask how many people, at that time, believed that we could reach the moon within twenty years, or what the impact of the transistor would be on the economy and society. CSP's latest market forecasts predict that by the year 2000, commercial space revenues will top $50 billion per year (1984 $). To put this figure in perspective, let me point out that the personal computer market had sales of approximately $20 billion in 1984, while total sales of the domestic steel industry reached roughly $42 billion.

The activities which CSP has analyzed range from extensions of existing industries (most notably satellite communications), to privatization of government-developed activities (remote sensing satellites and launch vehicles), to the commercial development of entirely new activities (materials processing, on-orbit services and hardware). Within a couple of generations, it is conceivable that we will be expanding beyond our planet, mining asteroids and the moon, deriving significant amounts of power from the sun, and indeed, even living in space.

Placed in the context of where we as a nation will be in the future, space will play an increasing role in our economic health and international competitiveness. The vitality of our computer industry owes part of its success to the support it received through NASA space programs; many of the high performance materials incorporated into today's products likewise trace their origins to materials research conducted in support of our space program. These activities have helped to maintain our international competitiveness in high technology, despite low foreign wage costs, trade barriers, and skewed exchange rates. It is therefore no surprise to those of us who are in the space industry that our European, Japanese and Canadian allies show increasing interest in space: they recognize that it has been a cornerstone of American technological and economic power over the past three decades, and they intend to become full-time players in the space arena.

It is important to recognize at the outset that we should not juxtapose expenditures on civilian space programs (and specifically those that support commercial development) with the social programs supported by the government. The ultimate beneficiary of commercial space activities, whether it be through new products, new technologies, jobs, or an enhanced economy, is the U.S. citizen and the U.S. taxpayer.

Clearly, however, we must deal with space commercialization from a pragmatic point of view. Developing space is an expensive proposition: our current national investment in civilian space programs since 1958 is over $200 billion in 1984 dollars. For twenty-six years, the American taxpayers, through the NASA budget, have financed the development of an impressive capability in space. We have proven the basic concepts of manned and unmanned space flight, developed a tremendous reservior of scientific and engineering data, and demonstrated time and again the resourcefulness of American industry to tackle and conquer new technological challenges.

Over the past few years, it has become clear that we are on the threshold of a new era in space. We are moving from a time of historic and heroic feats of exploration into one in which the expansion of industrial activity is increasingly feasible. It is a proper time to take measure of the future, so that the Federal Government may best support its mission for the citizens of the United States and its role in the world.

II. THE ROLE OF GOVERNMENT IN THE DEVELOPMENT OF NEW INDUSTRIES

It is tautological, but nonetheless important, to note at the outset that commerce occurs when it is profitable. Simply put, the private sector invests when it perceives that an economic return can be made on capital that takes into account its opportunity cost at an acceptable level of risk. If the return is too low, or the perceived risk is too high, investment will not occur.

This situation, while a perfectly legitimate standard for the allocation of resources in established industries, is often inappropriate for emerging ones. Frequently, these industries lack both the technological infrastructure (e.g. a reservoir of basic and applied research) and physical infrastructure (e.g. transportation systems) that have been built over decades in existing industries. A chicken-and-egg situation exists in which the private sector will not invest in infrastructure for an undeveloped market because the risk is high and the payoff uncertain. On the other hand, those who would use the infrastructure await its construction before commiting their own capital.

Since the foundation of our nation, a proper role of government has been to use its power to break this deadlock and prime the pump of new economic activity. It has been recognized that the government must create an atmosphere conducive to creativity and enterprise. This atmosphere is created through investment in the "prerequisites" of economic activity and in the creation of a stable policy and regulatory environment that makes investment planning more predictable.

There is considerable historical precedent for the provision by the government of the infrastructure necessary to promote commerce. Examples include the support of the merchant marine in the eighteenth century, the railroads and the canals in the nineteenth century, and the aircraft industry in our own century. Gentle government assistance is a solution to the chicken-and-egg problem: by providing the necessary initial conditions, the government sets in motion the desired commercial activity of the private sector, and society as a whole enjoys the fruits of the investment.

The Federal government has played a major part in the maintenance of the U.S. competitive position through its support of basic research. According to recent NSF data, the Federal government accounts for approximately seventy percent of all basic research funds spent in the U.S. over the past thirty years. If we look at the industries where the U.S. maintains a competitive edge today, we find industries that are based upon a strong technology base that has been supported by the government.

The wide range of policy instruments available to the government, including regulatory and tax policy, also play a critical role in the development of those new industries where financial, technical and market risk is usually higher than in established industries. Leaving aside the larger question of tax reform and initiatives designed to support specific activities, it is clear that a costly regulatory regime can hinder emerging industries. Not only can regulations raise the hurdle rates of specific projects, but the perception that new regulations may be on the way will encumber already risk-laden enterprises with another layer of uncertainty.

III. THE ROLE OF THE GOVERNMENT IN SPACE COMMERCIALIZATION

With respect to space activities, the government is in a position to influence strongly any commercial development. The high cost of working in space is the principal reason, since only the government has the power to make palatable the extraordinary risks associated with space at the present time. As well, the government is still the dominant player in space, and its actions and programs have an indisputable impact on the private sector. If we draw upon our historical experience, it is evident that the same principles which have guided the growth of our country from its inception to the present day are as valid in the context of space commercialization as they have ever been. For space, these principles may be enumerated as follows:

1. The Federal government must continue to support the development of basic research and technology development required for full commercial exploitation of space;
2. The Federal government must continue to invest in the development of high-leverage generic space infrastructure, such as the STS and space station, which encourage private investment;
3. Government must enhance the predictability of risk management by creating a stable space policy and regulatory framework; it should strive to eliminate government-induced barriers to the commercialization of space.

These principles are already codified in many of the legislative acts and executive initiatives that are "on the books". For example, it is an explicit premise of the President's National Space Policy to "provide a climate conducive to expanded private sector investment and involvement in civil space activities." To a commendable degree, the government has done a great deal already in the establishment of an advanced Space Transportation System, considerable ground support of activities in space, and the initiation of a Space Station program.

Having build the Space Shuttle, it may be tempting to the Government to step back and declare that it has done its share in the commercial development of space. At a time when the Federal budget deficit has become a critical problem, this sort of curtailment may seem especially appealing. We believe that, on the contrary, this course of action would be harmfully shortsighted. The Shuttle program was never envisaged as an end in itself, but as the next logical step for developing the ability to use space on a routine basis. It is one critical component, but not the only one, that we must develop.

IV. SPECIFIC BARRIERS TO THE COMMERCIALIZATION OF SPACE AND INITIATIVES WHICH THE GOVERNMENT SHOULD UNDERTAKE

In order to understand more fully what the Federal government can do to stimulate enterprise in space, it must be recognized that there are both issues of concern to all commercial operations, and those which affect only a few market segments. For example, almost all industries are affected by tax policy, and especially by the availability of tax credits that help to finance the heavy, up-front capital costs of space ventures. On the other hand, the risks faced by the commercial communications satellite business are quite different from those facing materials processing in space (MPS). Therefore, it is useful to consider government's role in these terms: What are the industry-wide barriers, and what are the barriers to specific industry segments?

A. PHASE III PRICING

One key variable which affects commercial potential is space transportation: what will it cost, how reliable is it, and how available is it? The issue of space transportation has become one of the current debates in the industry because of the competition for payloads between the government's space shuttle and a number of private firms that wish to sell expendable launch vehicles (ELV's). Several issues are interwoven in this debate.

First, there is a debate between proponents of ELV's and the supporters of the Shuttle as to the existence and extent of subsidy of the Shuttle program. No one argues that the present cost of the Shuttle, and indeed the cost through the end of FY 1988 ("Phase II pricing") is below full cost. It was recognized from the beginning that the Shuttle will not fly economically until it achieves a high flight rate. A recent CBO study notes that two thirds of the Shuttle program's costs are fixed; hence, a low flight rate implies a high per flight cost.

The pricing schedule for "Phase III" (i.e. beginning in FY 1989) is to be predicated upon "full cost recovery". In short, commercial customers (the bulk of the payloads are communications satellites) are asked to pay the full fare for their use of the Shuttle. The two camps have split over the definition of full cost recovery. Proponents of ELV's argue that the Shuttle should be priced on the same basis as ELV's. This means taking the entire Shuttle program operations and support costs and dividing by the flight rate. This would give the cost per flight; commercial users would then pay based upon their portion of utilization per flight. Under this definition, the commercial/foreign launch price basis would be $150-200 million, depending on whose figures one uses.

NASA has contended that this pricing formula is unfair to the private sector and would have deleterious consequences for not only commercial programs, but for the NASA and DoD space programs as well. NASA's approach to full additive cost of flying the commercial customer. NASA argues that a high percentage of the Shuttle program's costs would be incurred to support Federal space objectives irrespective of commercial utilization. It is unfair, NASA says, to burden the private sector with the maintenance of facilities and personnel whose main purpose is to support NASA and DoD. Instead, the commercial customers should pay for the augmented costs only. This would include all of the variable costs (additional manpower, facilities, hardware) needed to support a higher flight rate.

NASA also notes that it must compete with the Ariane launch vehicle. It is not known to what extent the Ariane program is subsidized, but it is clear that as a priate French corporation with close connections to the European capital community, Arianespace can offer financing packages and incentives that are unavailable to users of the shuttle. Ariane's prices are also lower than those of the Delta and Atlas Centaur ELV's. Hence, NASA persuasively notes that raising Shuttle prices to make U.S. ELV's more competitive will have the unintended affect of making the Ariane the launch vehicle of choice to a majority of commercial customers.

The Federal government is faced with a difficult question: acceptance of NASA's definition of full cost recovery (and a commercial/foreign launch basis of $87 million in 1982 dollars) will make it difficult, if not impossible, for commercial launch companies to compete. Analysis of the historical evolution of the program, and of the implications for the long term development of space, however, resolve one to support the NASA position.

First, the decision to proceed with the Shuttle program in the 1970's was predicated upon the phase-out of ELV's and the usage of the Shuttle as the primary launch system for both government and commercial needs. The interest in commercial ELV's developed in the late seventies and early eighties when the surge in commercial communications satellite launches led many to conclude that a four orbiter fleet would not be able to accommodate all users. ELV manufacturers and would-be operators asked the government for a policy which would enable them to offer the government-developed systems to the public directly. It was assumed that despite their higher price, ELV's would be able to find a niche because of insufficient supply in the aggregate, and because some users would be willing to pay a premium for the flexibility afforded by a dedicated launch.

A grievous error was made. Rosy market forecasts were predicated upon what might be termed a "linear fault". The growth which occurred at the beginning of the decade was expected to continue; studies projected up to fifty commercial communications satellite launches per year. In practice, this has not occurred. A current glut of transponder capacity has made it difficult for the current heavyweights of the satellite industry, and new start-ups have found it impossible to raise capital. Direct Broadcast Satellites, which were seen to be a major source of growth, have encountered skepticism in capital markets, and many DBS companies have rescinded their plans to pursue the market. In short, there was a miscalculation on the past of ELV manufacturers as to the size of the market.

Faced with a declining market, it has become clear that ELV's cannot fill the "overflow", and practice has shown that communications satellite companies are satisfied with the flexibility of the Shuttle and Ariane. ELV manufacturers, therefore, have asked for a change in the rules. They have argued that Shuttle prices must rise to a level where they can compete, communications satellites must be taken off of the Shuttle, or some combination of the two.

The net effect of this policy would be to harm the entire space industry and government space programs in order to support a handful of companies providing launch services.

The communications satellite market (estimated to generate $20 billion in revenues by the year 2000) would be hurt immediately through higher launch costs. Launch costs already comprise about 50% of the total cost of a satellite system; doubling that cost would have one of two results: either costs would rise significantly (costs which would end up being paid by consumers) or communications satellites would become economically unviable (killing demand altogether).

Nascent commercial space industries, and especially the materials processing industry (estimated by CSP to generate $27 billion in revenues by the year 2000), would also be affected. The high cost of space transportation is already a significant problem for an industry which is still largely in the R&D stage. This is especially true now, when there are few alternatives to manned experimentation on the Shuttle. Whereas the cost of launching a communications satellite can be "credited" against its ten year revenue stream, a materials processing experiment lasts only as long as the duration of a Shuttle flight. Hence, the cost must be absorbed quickly, and if no product is produced, there are no offsetting revenues. If there is space-based production (the MDAC-Johnson & Johnson CFES apparatus will produce clinical testing samples on the next STS flight), the impact of a rise in price is severe. In testimony last month, Mr. Jim Rose noted that eleven potential products were identified as profitable under the Phase I pricing scheme. Under NASA's Phase III price of $87 million, only four remain profitable. A rise in price to $150-200 million would likely eliminate these remaining prospects.

Some have argued that the removal of communications satellites from the NASA manifest would spur materials processing, by freeing up the Shuttle for those activities where the Shuttle's "unique attributes" can best be used. This may be accurate in theory, but in practice is just sleight-of-hand. MPS experiments simply do not take up enough volume to fill the Shuttle as quickly as satellites. The net effect of approving policies that implement this proposal would be a reduction in the flight rate, and a corresponding increase in the cost per flight. At this point the Government would have two alternatives: (1) have MPS payloads carry a higher transportation cost (which would effectively preclude much of the R&D which is needed to launch the industry), or (2) subsidize MPS payloads with taxpayer money. Neither seems to be in the nation's longterm interest.

A rise in Shuttle prices would also hurt a broad number of companies that have invested millions of dollars (in fact, much more than the amount expended by ELV manufacturers) to develop Shuttle upper stages (the McDonnell Douglas PAMs, the Orbital Sciences Corp. TOS, the Astrotech DATS and others). Other companies, such as Fairchild, which have developed on-orbit space hardware, would find it difficult to garner customers when the number of activities possible using the Shuttle is constrained by a pricing schedule driven by the interests of the ELV industry.

Finally, the cost for government missions also would rise. At a lower flight rate, Government would lose manifesting flexibility, and would be likely to face higher costs for the launch of government payloads. Given the general pressure on the Federal budget, the likely impact of a rise in launch costs would be a decrease in the number of missions which NASA could fund.

1. The Shuttle is the bridge to profitable commercial operations for every commercial endeavor except the ELV industry. A high Shuttle price, dictated by a desire to create a market for a few firms, is not in the long term interest of private industry as a whole, the government, or the citizens of the United States.

A related issue concerns the charges which foreign governments and private entities must pay to use the Shuttle. As noted above, development costs for the Shuttle, which were paid for with taxpayer money, are not included in the price calculations (nor, incidentially, are they included in Ariane's price, nor those of the Delta and Atlas Centaur vehicles). One can argue that this is appropriate, and that the U.S. users of the Shuttle have helped to finance the devlopment through their tax dollars.

For foreign customers, this is not always the case. From the beginning of the Space Age the United States has sought to promote international cooperation in space, and the country has done a commendable job in carrying out this mandate. However, cooperation need not be extended to the point of permitting potential competitors to enjoy the use of facilities to which they have not contributed. It would seem logical that the United States should not be in the business of subsidizing foreign commercial usage of space.

2. A small premium (perhaps 2-3 percent) should be charged to foreign commercial users of the Shuttle.

There would need to be exceptions to this rule, however. The first would be that those countries which have participated in the STS program should be exempt: for example Canada supplied the Shuttle Remote Manipulator System, and ESA countries developed the Spacelab. Secondly, the premium should be waived in those instances when it is considered in the foreign policy or national interest of the United States—such as when developing countries launch satellite systems.

The budgetry impact of this policy would likely be minimal. Nevertheless, as we plan for the future, and the space station endeavor, it is important to codify the principles governing foreign utilization of assets that have been funded by the U.S. taxpayer. This is especially true when we are dealing in a competitive arena in which U.S. firms will be competing with foreign entities, both public and private.

B. TIERED PRICING

In addition to supporting NASA's current pricing proposal, we believe that the Congress and the Administration should urge NASA to explore tiered pricing schedules. One of the major problems with which NASA must deal is the inability to accommodate the varying risks of different payloads. Two pricing schedules currently exist: customers can pay based upon the official price basis, or they can ride at no monetary cost if they qualify for a Joint Endeavor Agreement.

Conceptually, there are three types of risk faced by a space business. These are technical risk, financial risk, and market risk. Technical risk exists when a technology is being developed that has not been used in space before. For example, Microgravity Research Associates is pursuing a new crystal growth technique in space that pushes the frontier of process technology. Financial risk exists when significant schedule delays are possible, and these result in cost overruns. For some activities, the cost of dalay is high in terms of maintaining manpower, hardware flight readiness, and so forth. Market risk exists when the firm intends to produce a new product or service which has not existed before. For example, Fairchild's Leasecraft program is intended to serve the commercial MPS market and undetermined NASA payloads—there is no guarantee that users will materialize for the system.

3. NASA should develop tiered pricing which accounts for the varying levels of risk assumed by the private entity.

4. The amount of support which NASA provides to a private entity should be in inverse relation to the amount and type of risk encountered.

5. The government should not mitigate or alleviate market risk only.

Communications satellites present an example of an industry which does not need to be given a tiered-price discount. The technology employed in satellites is well known, as are the financial and market parameters. The maturity of the industry is established and competitive forces, rather than technical or financial uncertainty, are the key risks faced by satellite forms. It has always been incumbent upon the private sector to evaluate these risks and act based upon informed judgement. NASA and the Government should not intervene.

At the other end of the spectrum is materials processing research. Technical risk is high, since must of the work which is currently contemplated involves penetration into new areas where the results cannot be predicted with accuracy. Financial risk is also great, because of the impact that delay has on business plan financials. Market risk is also great, because often the research is oriented toward new products which have never been tested, and exist only on paper. For this type of risk the Joint Endeavor Agreement is appropriate. NASA typically derives some benefit from access to the knowledge or hardware used by the firm, and the venture receives a valuable reduction in flight costs.

In between lie a number of projects which have less risk than the preceding example, but more than pure market risk. An example of this type might be the commercial production of space hardware "utilities", or the development of a commercial demonstration project. For these kinds of ventures, the technical risk is less than in the preceding examples: the basics are well understood and the project usually has no great unknowns from this angle. Financial risk and market risk might still be substantial however.

A full JEA is difficult to justify in this situation; however, if one looks at the needs of the private firm, solutions are possible. The private firm wants to minimize risk by lowering its financial exposure. If NASA can help by making transportation cost payment coincide with the generation of revenue, then the viability of the venture would increase.

One solution would be a change in the payment schedule, such that a portion, or all, of the launch costs could be deferred until after the launch. A second option might be a "modified JEA" whereby NASA grants a free launch, or a reduction in the launch price, in exchange for a royalty agreement based on future revenues. This agreement would have a cap that would be based upon the value of the launch concession. For example, if a launch worth $20 million was granted, NASA might take a royalty on sales that would be effective up to the point that cumulative royalties equaled $20 million, adjusted for inflation. Numerous other permutations on this basic theme are possible, based on the nature and degree of risk associated with a particular venture.

A third possibility is a government guarantee to use the commercial product or service. In practice, this is difficult because of the restrictions on multiyear or future year procurements, and because reliance upon commercial development could place NASA missions dependent upon a specific input at risk if they do not materialize or do not perform as expected. Again, however, compromise would seem feasible: NASA could make the grant of a concession contingent upon satisfactory progress reports. Congress could also allow NASA to "bank" a certain amount of its budget for future purchase of commercial products that would support NASA's efforts.

C. FEDERAL R&D AND INVESTMENT TAX POLICY

Compared with enterprise on Earth, space ventures have two inherent problems: up-front capital costs are usually very large, and the payoff period is relatively long. Much of commercial space can be termed an infant industry laboring under the capital requirements associated with more mature industries.

In structuring a business plan for a commercial space venture, entrepreneurs must seek all means to attempt to remedy this situation. The up-front capital costs, however, can rarely be deferred, and it is difficult to finance space hardware through debt financing, especially when there is market uncertainty and few physical assets to act as collateral. Instead, most ventures which have obtained capital have relied on tax incentives such as the R&D limited partnership, and the Accelerated Cost Recovery Schedule, in order to reduce the tax burden on the firm during its early years. These mechanisms allow firms to retain a greater percentage of the profits during the early years of a project. From a business plan perspective, this always means an increase in the net present value of the firm and its internal rate of return. Often, it can help to reduce the total amount of outside financing which a firm must obtain.

Tax incentives which are intended to spur investment in high technology are especially critical to space businesses. Of the numerous business plans which CSP has reviewed, none would even be considered without the benefit which these tax policies offer. We believe that this is important to note as the Congress and the Administration are examining a major tax reform package which could eliminate these benefits.

6. As a matter of national policy, tax reform must be considered not only with an eye towards the immediate problem of deficit reduction or improved equity of the tax system, but must also consider the long term consequences to the capital investment and technology development process which are keeping the United States at the forefront of the world economy.

D. FEDERAL AND STATE TAX POLICY

Overlapping jurisdictions and the interests of state governments to derive tax revenues from commercial space enterprises pose a potential problem for commercial space firms. The case of Comsat v. Francise Tax Board is illustrative of this point. In short, the state of California claims that because Comsat has earth stations in California, it is entitled to tax the revenues earned by Intelsat satellites. A clear potential exists that this extension of territorial prerogative by states could place severe burdens on other satellite operators or commercial ventures. A remedy for this situation may be forthcoming from the Court. In its absence, it is clear that the Federal government must take the initiative to define where states' rights to tax space-based commerce begin and end.

V. CONCLUSION

These are just some of the issues which are facing commercial space enterprise. These issues are topical, and the decisions taken by the Federal government over the course of the next year or two will materially affect our nation's commercial future in space. We believe that the potential of space warrants the dedication and concern of all in industry and government.

We thank you, Mr. Charman and members of the subcommittee, for the opportunity to express our views to you today. We will be happy to answer any questions which you may have.

Senator GORTON. Mr. Lippy, you got a lot of words in in 5 minutes.

Senator ROCKEFELLER. Mr. Chairman, I was going to suggest that Mr. Lippy talks like Mozart writes, rapidly.

Senator GORTON. And very good words, too, I might add. We thank you.

Mr. Ferguson.

Mr. FERGUSON. Thank you, Mr. Chairman.

I appreciate this opportunity to present this morning the views of Orbital Sciences Corp. regarding the price of the National Aeronautics and Space Administration's Space Transportation System and other issues that affect the commercialization of space.

The level and direction of commercial space activity are clearly of long-term strategic and economic importance. However, for OSC and for other companies like us who have actually invested millions of dollars in communications satellites, upper stages, microgravity electrophoresis, or space platforms, the issues of commercial space take on an immediacy that may not be felt by companies still in a study or promotional phase.

A decision this year to increase the post-1988 shuttle price, for example, would seriously jeopardize our ability to market to commercial communications satellites which currently constitute nearly half of our projected market in the late 1980's and 1990's.

The perspective OSC offers, then, is on the issues important to current rather than prospective or contingent commercial space efforts. It is my belief that the success or failure of these current efforts will greatly influence the growth rate of future commercial space activities.

From our standpoint, the three key issues in order of priority are shuttle pricing, Government procurement policy, and tax policy. Shuttle pricing ranks highest in importance because it governs whether or not the space environment is accessible to commercial endeavors.

There are five general arguments why I believe that post-1988 shuttle prices should remain low, ideally in a flexible range between NASA's short-term and long-term marginal costs.

The first reason is that the real prospects for space commercialization rest with the shuttle. Investors have recognized this, placing over 10 times as much capital into shuttle-based commercial space firms as into the proposed private ELV projects, and the ratio is much higher if private communications satellites are counted.

The second reason is that the cost advantages of the reuseable shuttle are very sensitive to flight rate, which in turn is sensitive to the prices charged to shuttle customers. Establishing a low price helps to ensure that the high fixed operating costs of the shuttle are spread over a large number of missions. For this reason, when the shuttle becomes fully operational, I believe that current domestic ELV's I believe will be unable to compete with it on a cost basis. And for this reason also, Mr. Chairman, although it seems something of a paradox, a full-cost price will not lead to full cost recovery, which is the goal of this administration.

My third argument is that a higher shuttle price would serve only to benefit subsidized foreign launch systems. The Ariane rocket in particular, as has been mentioned, consistently priced to defeat the shuttle, would continue to be priced to defeat domestic ELV's. Each payload lost to a foreign launcher means a loss to the U.S. economy of anywhere from $35 to $70 million or more, plus an inestimable possible loss should the overall U.S. lead in the worldwide telecommunications market begin to erode. Shuttle pricing policy should reflect the realities of the international market.

Fourth, the market for launch services through 1990 does not appear sufficient to support domestic ELV's, given shuttle and Ariane capacity and given the recent decision by the Air Force in its agreement with NASA to institute a CELV production line. In such an environment, raising the shuttle price to help domestic ELV's is unlikely to have its intended effect.

My final argument is that the reuseable shuttle represents a bold step forward in space technology that other countries even now plan to emulate. A drastic increase in shuttle price will decrease the rate of accumulation of flight, operations and maintenance experience necessary to maintain our lead in a broad range of launch service technologies.

Government procurement policy is also important to current commercial space enterprises for three reasons:

First, the Federal Government is the largest single customer for aerospace hardware and services.

Second, commercial customers have historically waited for Government's demonstration of new space systems before purchasing such systems themselves.

And finally, the size and timing of the potential market represent the largest risk faced by most commercial space enterprises.

In my written statement I recommend a number of possible Government procurement initiatives that would encourage commercial space activity, and I similarly recommend several tax initiatives that would help to improve the return on investment of commercial space projects, and thereby reduce somewhat the risk of investment. The high capital requirements and long-term payback of commercial space enterprises can readily be addressed by tax law amendments.

Correct policy decisions on the issues of shuttle price, Government procurement, and tax structure should help to ensure a robust U.S. presence in emerging global industries.

Thank you.

[The statement follows:]

STATEMENT OF BRUCE W. FERGUSON, VICE PRESIDENT/FINANCE AND GENERAL COUNSEL, ORBITAL SCIENCES CORPORATION

Mr. Chairman and Members of the Subcommittee: I appreciate this opportunity to present the views of Orbital Sciences Corporation (OSC) regarding the price of the National Aeronautics and Space Administration's (NASA's) Space Transportation System (or Space Shuttle) and other issues that affect the commercialization of space.

I. INTRODUCTION

OSC was formed in 1982 to finance the development of low-cost, high-capacity upper stages for use on the Space Shuttle. OSC is currently developing the Transfer Orbit Stage (TOS™), the Apogee and Maneuvering Stage (AMS™) and the two-stage TOS/AMS™. These upper stages are designed to transport their satellite payloads from low Earth orbit of the Shuttle to higher orbits that the Shuttle cannot reach, such as geosynchronous orbit and planetary trajectories.

Commercial development of OSC's upper stages is predicated on the need for cost-effective, medium capacity upper stages that enable the Shuttle to compete effectively with the French Ariane IV and V expendable launch vehicles (ELVs). Before the advent of OSC's vehicles, no upper stage system could competitively launch communications satellites and other spacecraft of the AMS, TOS, or TOS/AMS class from the Shuttle. Recognizing the need for upper stages to enhance the Shuttle's competitive and operational capabilities, NASA and OSC have signed a series of cooperative agreements providing that OSC will commercially develop its upper stages using private funds and at no charge to the Government.

OSC has contracted with Martin Marietta Corporation for development and production of its upper stage vehicles. In fact, I returned just last night from Martin Marietta's Denver Aerospace Division, where nearly three hundred people are attending the Critical Design Review for the TOS development program, the last major milestone before fabrication and testing. I am happy to report that the program is still under budget, thanks to the careful management of Martin Marietta's Peter B. Teets, Richard E. Brackeen and Richard J. Farrell, as well as OSC's own Frank L. Van Rensselaer, John H. Mehoves and Axel M. Larsen.

OSC has invested more funds from private capital markets than any other company in the history of United States space transportation. For example, OSC manages the largest research and development limited partnership ever offered in the aerospace industry, Orbital Research Partners, L.P., which funds the development of the TOS and of TOS-based technology in the AMS and TOS/AMS. This partnership, which raised $50 million from over 900 individual investors, was completed last year by Shearson Lehman Brothers and Rothschild Inc., and with other equity and debt investments makes OSC the most strongly capitalized new space company in the country.

For us, and for the other companies that like us have actually invested millions of dollars in communications satellites, upper stages, microgravity electrophoresis, or space platforms, the issues of commercial space take on an immediacy that may not be felt by companies still in a study or promotional phase, or by managers with a ten-year horizon on bringing products to market. Nearly half of the projected market for OSC's upper stages in the late 1980's and early 1990's, for example, is comprised of commercial communications satellites, a market that would be seriously jeopardized by a decision this year to increase greatly the post-1988 Space Shuttle price. The perspective OSC offers is on the issues important to current, rather than prospective or contingent, commercial space efforts. In order of priority, these issues are Shuttle pricing, Government procurement policy, and tax policy.

II. THE SPACE SHUTTLE SHOULD BE PRICED AT MARGINAL COST

There are five general arguments why I believe that Shuttle prices after 1988 should remain low—ideally at NASA's marginal cost. First, NASA, which decided to abandon older-technology ELDs like Delta and Atlas in favor of the Shuttle, has through its development of the Shuttle confirmed our country's technological lead in space launch services. This technological lead in space technology depends in many respects on the accumulation of flight, operations, and maintenance experience with manned, reusable launch systems and is not guaranteed to persist: the Soviets, French, Japanese, and British all propose to build reusable launch vehicles. A Federal policy, such as a drastic increase in Shuttle prices, that fails to maximize the Shuttle flight rate also will fail to maximize the United States advantage in a broad range of space launch service technologies.

Second, the Shuttle is more economically efficient than United States ELVs. Because a large portion of the Shuttle's costs are fixed, its operational costs are particularly sensitive to utilization rate. The Shuttle's flight rate should double by 1988, essentially halving the per-mission allocation of its fixed costs. Moreover, with only fifteen flights completed out of some 225 planned for the Shuttle over the next ten years, significant learning efficiencies are yet to be realized. In contrast, Delta, Atlas, and Titan each have flown over 100 times and, consequently, have negligible expected learning curve economies as compared with those for Shuttle, Ariane, or other new foreign entrants in the launch market. For these reasons, when the Shuttle become fully operational, its average launch cost should drop to less than $84 million (all prices are in 1982 dollars). Current domestic ELVs will then be unable to compete with it on a cost basis.

Nor is it clear that average cost is the proper yardstick for the Shuttle price. In an efficient competitive marketplace prices tend toward the lower marginal cost rather than average cost. Because of its reusability, marginal costs for the Shuttle are far lower than comparable costs for United States ELV's. By setting a price above marginal cost, the Government would in effect be subsidizing inefficient private producers. Further, private ELVs would be likely to require direct subsidies as well, because their manufacturers cannot afford to pay full value for the extensive government equipment and facilities necessary for launch and still hope to compete successfully with Ariane.

According to a study released two weeks ago by the Congressional Budget Office, Options for the Space Shuttle, the price of $71 million in effect beginning FY 1986 would more than cover the short-run marginal cost of a hypothetical commercial seventeenth mission over a base of sixteen NASA and DoD missions. Even a price as low as $71 million means in fact that commercial users will subsidize the Government. The magnitude of the subsidy increases as the price increases over $71 million. One can well ask if it is desirable for ordinary citizens using satellite communications services to be expected to subsidize government and military payloads over and above their tax burden. In this regard, the Congressional Budget Office noted in recent testimony before the United States House of Representatives that there are numerous precedents for sales of federal assets (power, lumber, oil) at prices approximating marginal cost even where there is private competition.

My third point is that industrial growth and job creation in the commercial space industry over the next ten to fifteen years depend on the Shuttle and its unique capabilities far more than on ELVs. Areas of enormous commercial promise in advanced communications, materials processing, remote sensing and orbital transportation depend on the reusable, manned Shuttle for realization. These endeavors cannot adequately be served by expendable rockets. Hence, the expansion of future commercial activity in space depends on the unique attributes of the Shuttle, and current private capital at risk reflects this fact. Private investors, both individuals and institutions, have placed over ten times as much capital into the more than thirty commercial space firms dependent on the Shuttle as has been invested in five United States ELV projects underway. In the initial phase of commercial space ventures, private capital markets have voted unambiguously for Shuttle-based projects. Thus, while ELV proponents argue that a higher Shuttle price will promote the commercial development of space by establishing private ELVs as an early success, it is instead evident that the real prospects for space commercialization rests with the Shuttle.

My fourth argument concerning the Shuttle price is that there is an insufficient market to support the United States ELVs. The Shuttle and Ariane will each shortly possess sufficient capacity to satisfy 80% to 100% of the demand for commercial satellite launch service through 1990. In other words, there will soon be twice as much supply as demand for launch services. In addition, the recent announcement by the United States Air Force of its Titan procurement guarantees the availability of an open ELV production line for at least six more years. This fact provides a margin of safety against the unlikely loss of an orbiter or an unexpectedly rapid increase in launch service demand in the next seven years. In such an environment, raising the Shuttle price to help United States ELVs is both unnecessary and unlikely to have its intended effect.

My final argument is based on the fact that the Shuttle provides relief to problems in the balance of trade that domestic ELVs do not. If a dramatically higher Shuttle price were announced this year, then intensified foreign competition would be created by encouraging Arianespace to expand its capacity and by encouraging new foreign launch service operators to enter the market. Because of state subsidization and production and operational advantages, these foreign launchers, especially Ariane, would prevail over older United States ELVs in such a market environment. The Ariane rocket in particular, developed by government-subsidized European consortium and consistently priced to defeat the Shuttle, would continue to be priced to defeat private ELVs. Nor is a serious effort being conducted by United States ELV companies to develop state-of-the-art vehicles that can compete effectively with Ariane.

Each payload lost to a foreign launcher means a loss to the U.S. economy of $35–70 million or more—a total approaching $1 billion a year by the early 1990's. If other technology or service markets follow a shift to foreign launch systems, the revenue lost per mission to the United States economy could be two or three times as much.

The size of the total worldwide telecommunications market goes far beyond simple launch services, and its value cannot be measured solely in terms of dollars. Technological initiative and prestige also rest with the dominant world supplier of telecommunications products and services, and the principal launch service provider plays a key role in shaping the telecommunications industry. At a time when the United States must be more determined to meet foreign competition than ever before, and particularly so in the industries that will spring from the space technology and services of the next decade and beyond, the policy for Shuttle pricing should reflect the reality of the international market.

II. GOVERNMENT PROCUREMENT PROCEDURES SHOULD ASSIST SPACE COMMERCIALIZATION

The procurement procedures followed by the Government may play a critical role in the success of many commercial space firms for three reasons. First, the Federal Government is the largest single customer for aerospace hardware and services by a wide margin. Also, commercial customers have historically waited for Government demonstration of new space systems before purchasing such systems themselves. Third, the size and timing of the potential market represent the largest risks faced by most commercial space enterprises.

Procurement as an aid to commercialization is a valid goal in the public interest because private funding of space hardware can provide alternative sources to Government-funded hardware, lowering costs through competition, and can provide new technologies, products and capabilities to the Government. Increased use of private financing can lessen the public burden by leveraging tight NASA and the Department of Defense budgets, leaving more funds for basic science and higher risk R&D where commercialization has less to offer. Thus, so long as standards of performance and reliability satisfy Government needs, and so long as agency goals are furthered, privately financed development significantly benefits the public and should be encouraged through the procurement process. This conclusion justified a close examination of current procurement procedures to determine if they raise any barriers to the commercialization of space. I believe that standard Government procurement procedures currently leave privately funded systems at a distinct, if unintentional, disadvantage in relation to systems developed with Government funds.

There are three explicit policy positions recently promulgated by the President, Congress, and NASA which support the Government's proper use of procurement techniques as a means to foster commercialization:

1. The President's National Policy on the Commercial Use of Space, 20 July 1984, indicated the intent to "facilitate long-term contracts with new space ventures if the government has a need for the product and if the purchase would be cost-efficient."
2. The 1984 Space Act amendment (HR-5713, 98th Congress) calls for NASA "to seek and encourage, to the maximum extent possible, the fullest commercial use of space."
3. NASA's Commercial Space Policy, issued 19 November 1984, calls for selective NASA purchase of commercial space products and services to stimulate industrial development of space.

The Government can overcome the barriers to space commercialization that rest in the current procurement system by granting specific recognition to competitors that have funded product development programs with private capital. The specific recognition could take the form of a positive credit for private funding that offsets the advantages enjoyed by publicly-funded alternatives. Such an award of a positive credit for commercial development should attempt to create equal standing among competitors, not give a preference to privately-funded development.

This positive credit can take a variety of forms that are consistent with current law and can be implemented with little effort or expense, such as:

1. Use of commercial funding as a tiebreaker in procurement;
2. Use of commercial funding as a selection criterion in addition to the traditional criteria employed by Source Evaluation Boards in competitive procurements;
3. Nomination of a respected agency executive to Source Selection Boards as commercial funding advocate, analogous to a competition advocate, whenever a commercially funded program is competing against a Government-funded program. This advocate's primary responsibility would be to facilitate a fair hearing for the commercial program;
4. Creation of management review boards that, in parallel with Source Selection Boards, consider criteria representing broader Government goals; and
5. Utilization of current authority under the Competition in Contracting Act of 1984 to exclude established sources in competitions in order to establish or maintain alternative sources of supply.

Any of the above mechanisms could be employed this year in order to produce positive results for space commercialization before 1986. Hence, I believe that mechanisms are currently available to Government agencies that can and should be used to significantly promote space commercialization in the near term. However, a Government agency such as NASA should not be required to apply this positive credit if the program conflicts with agency goals. In addition, the positive credit need not be given as much weight in the evaluation as either cost-effectiveness or performance.

I believe that such explicit recognition of the positive value of priately financed development is necessary to ensure fair competition within the Federal procurement process between firms that are privately developing systems or items of hardware and those that are developing such systems or hardware at Government expense. More importantly, if the private financing of aerospace hardware development is a positive step in the transition to a commercial space industry—and OSC strongly believes that widespread private financing is a fundamental precursor of successful commercialization—then Government procurement procedures should encourage, not discourage, private financing.

III. THE TAX STRUCTURE SHOULD ENCOURAGE SPACE COMMERCIALIZATION

The President's National Policy on the Commercial Use of Space, 20 July 1984, clearly states that modifications to the tax law benefitting space projects are desirable. The maturation of the commercial space industry would be greatly assisted if Congress implemented certain tax incentives which would improve the return on the investment and somewhat the risk of the investment.

The commercial space industry has characteristics that should encourage Congress to provide tax incentives for investment. It may soon become one of the largest sources of technological innovation in the country, maintaining the United States lead in space technology and related areas such as robotics. However, the investment community perceives the commercial space industry as a very high risk industry with returns materializing further in the future than most competing investments. Moreover, the industry faces a significant barrier to entry: high capital requirements. This combination of high risk, long-term paybacks, and large funding requirements frequently discourages investment.

The following are particular suggestions for changes to the Internal Revenue Code of 1954, as amended, (the "Code"), that would reduce the financial hurdles faced by entrants to the commercial space industry:

1. Section 465 of the Code, which limits deductions for expenditures associated with a venture to the amounts "at-risk", should be amended to exclude commercial space ventures from the limitation of that provision. Such an exemption is not without precedent: real estate investment is currently exempt from the Section 465 limitation.

2. The restriction on the timing of deductions in Section 461 of the Code should be removed for space ventures to permit investors in such ventures to take deductions earlier and on more aggressive basis.

3. The research and development credit of Section 30 of Code should be amended to remove the requirement of carrying on a trade or business before the credit is available. Also, Section 30 should be amended to grant full credit for space ventures even if research work is contracted out. Finally, base period research expenses should no longer be limited to 50% of qualified research expenses.

4. Relevant provisions of the Code should be added or amended to permit space ventures to license or sell portions of the technology under development without jeopardizing future capital gains treatment on the final sale of the technology.

5. A tax credit for bid and proposal expenditures should be provided to companies without substantial Government contracts that must expend significant sums in preparing proposals for Government contracts for space hardware or services. This is especially justifiable in light of the fact that the Government reimburses established Government contracts for up to 80% of their bid and proposal costs.

By the turn of the century, today's commercial space efforts will result in new industries generating many billions of dollars in revenues. Low-cost access to space is vital to this result, and a low Shuttle price is key to maintaining such access. Almost as important, Government encouragement of commercial space activity through procurement mechanisms would help to reduce the high market risk facing most commercial space programs. Similarly, the financial risks of investment in commercial space enterprises can be mitigated through certain tax law changes. Correct policy decisions on the issues of Shuttle price, Government procurement and tax structure should help to ensure a robust United States presence in emerging global industries.

Senator GORTON. Thank you, Mr. Ferguson.

Now, Mr. Savoca, we have finally gotten to you.

Mr. SAVOCA. Thank you, Mr. Chairman, Mr. Rockefeller.

In this oral statement we will summarize two of the major issues: Commercial transportation in space, and space product development, both of which are interlocking in their relationship with the future and will have a major impact on our economy.

Decisions being made today will form the foundation of how the space business economy will develop for the future, and what impact it will have upon our existing economy. Transportation, although representing less than 10 percent of the existing economy, is a critical support element and it will maintain its importance as our economy expands into space.

The transportation lessons learned on land, sea, and air will not be different in space. Efficient and alternate modes of transportation must build up to support the developing space business. The administration's decision to commercialize the Delta and Atlas/Centaur expendable launch vehicles is timely and cost effective. It preserves for the U.S. alternate transportation modes when there are few existing.

It makes use of the billions of dollars of investment in development of Delta and Atlas/Centaur, and it provides a backup during the run-in period for shuttle operation.

However, the expendable launch vehicle industry cannot exist at the NASA-recommended per shuttle bay price of $87 million. At this price, the shuttle-subsidized ride to space will preclude the expendable launch vehicle from participating in that market.

The Presidential policy endorsing the commercialization of expendable launch vehicles reiterated the long-standing policy that the shuttle would go to full cost recovery starting in October 1988 for foreign and commercial launches. Without a full cost recovery policy for shuttle, TCI would not have attempted to make a viable business based on Delta. We are not asking for a change in the rule. We are asking for a continuation of the rule.

We have provided an analysis in our full testimony for the record that shows that full cost recovery for shuttle is at least $188 million for Fiscal Years 1989, 1990, and 1991, and is probably substantially greater than that. A $150 million commercial price per shuttle payload bay would allow Delta and Atlas/Centaur to be viable, given a successful resolution of the 301 petition against Ariane and would allow ELV's to compete without being dependent on subsidy.

The $150 million shuttle bay price equates to a $31 million price for a Delta class payload launched to low Earth orbit on shuttle, since NASA charges 20.7 percent of the shuttle payload bay price for each Delta class launch.

When NASA operated the Delta launch vehicle, foreign and commercial customers were charged the full recovery as the policy dictates, less consideration for return on investment and imputed taxes. These items were not considered because there were no commercial companies competing with NASA for the business at that time. As a matter of fact, during 1982, 1983, and 1984 NASA charged foreign and commercial customers $32 million per Delta launches to low Earth orbit.

Products made in space may require subsidy in research and development stages because of the substantial risk and capital required before they are proved out and submitted to the market for profit. However, products made in space and services provided from space will be sold on Earth and will compete with products and services already established in the market. For this reason, they should not be subsidized after they enter the market. If they are, they will cause products and services which are covering their full cost to fail if no countervailing avenue for subsidy is available to them.

Products and services so threatened will rightfully demand a Government subsidy to offset the subsidy given to the space products and services. The result will be increasing levels of subsidy and increasing instability in the U.S. economy. This will expand into international markets as space products and services are sold internationally, further compounding the already tangled web of international trade. And in this case, the United States would have the dubious distinction of setting the pattern.

In summary, we have commented on all of the issues requested of us, but in reality TCI must focus its efforts on one issue alone: That of commercializing the Delta expendable launch vehicle. Our efforts to do so are limited to the commercialization process outlined by the administration. Given these limitations, we suggest two possible solutions.

The first is to establish two prices for the space shuttle in the post-fiscal year 1988 time period, a subsidized price for research and development payloads, and a commercially based cost recovery price for foreign and domestic commercial satellite launches. This would result in competition for NASA in no more than 7 percent of their market.

The second is to decide that the Government not compete with U.S. companies for foreign and domestic commercial satellite launches. Both of these solutions would allow our Nation's free market to work in this for-profit sector to the economy.

Thank you, Mr. Chairman. I will be happy to answer any questions.

[The statement follows:]

STATEMENT OF ANTONIO L. SAVOCA, PRESIDENT AND CHIEF EXECUTIVE OFFICER OF TRANSPACE CARRIERS, INC.

Mr. Chairman and distinguished members of the Subcommittee: I am Antonio L. Savoca, President and Chief Executive Officer of Transpace Carriers, Inc. We greatly appreciate the opportunity to address the questions the subcommittee wishes to explore today concerning what is at stake in the future of space commercialization, the major barriers and issues related to the success of space commercialization, and the actions or initiatives needed to successfully realize the potential benefits of space commercialization. We are also happy to have the opportunity to address the subcommittee on the pricing environment in which the expendable launch vehicle industry, of which we are a part, finds itself. In particular, we want to address the impact that the NASA recommended Shuttle price for fiscal years 1989 and beyond will have on our emerging industry.

Before we answer the Subcommittee's questions, we would like to describe the current status of our Company. As you know, Transpace Carriers is operating under an agreement with NASA to transition the Delta Expendable Launch Vehicle to the private sector.

Our Company was incorporated in September 1982 under the laws of Maryland, specifically for that purpose. We followed the procurement procedures set up by NASA for this activity which culminated in an agreement between NASA and ourselves, reviewed and approved by the House and Senate committees, and executed by NASA on 16 May 1984, and legislation was passed in November, 1984.

TCI MANAGEMENT

TCI has assembled an outstanding senior management team with considerable experience in the aerospace industry. The combined experience level of these five individuals is 146 years of which 98 were specifically associated with the U.S. space program. The following is a synopsis of this experience:

David W. Grimes, age 47, has been a director and Chairman of the Board since inception and Vice President—Engineering since June 1983. Prior to forming the Company in 1982, Mr. Grimes was with NASA for 19 years, serving the last five years as Project Manager, Delta Launch Vehicle Program at NASA's Goddard Space Flight Center. In this position he was the senior executive responsible for the management of the $200 million per year launching vehicle business within NASA, including all facets of production, check-out. launch services, and customer support. He is recognized as a foremost expert in the field of spacecraft launch vehicle systems. He also served as Project Manager, Shuttle Spacelab Payload; Project Manager, Atmosphere Explorers; and Engineering Manager for the Orbiting Geophysical Observatories. Prior to joining NASA, Mr. Grimes was engaged in instrumentation engineering with Air Research, Lockheed, and Hercules. Mr. Grimes received a B.S.E.E. from West Virginia University.

Antonio L. Savoca, age 61, has served as President and Chief Executive Officer and a director since 1983. Prior to joining the Company he served for more than eight years as Senior Vice President, Morton Thiokol Corporation, and General Manager, Wasatch Division. He had profit responsibility for this $400 million, 4500 personnel operating division of Morton Thiokol and was involved in design, development and production of highly complex solid propellant rocket motor systems for space and military applications, including the Space Shuttle solid rocket motors. The previous six years, Mr. Savoca was director of finance and administration, Wasatch Division. He controlled and administered finance, contracts, proposals, procurement, personnel management, information systems, internal audit, and data processing. Prior to joining Morton Thiokol, Mr. Savoca served 21 years in the Air Force in a wide variety of increasingly responsible flight and management assignments attaining the rank of Lieutenant Colonel. Mr. Savoca received a B.A. in Business Administration from the University of Oklahoma.

George F. Page, Vice President, Operations. Mr. Page has 33 years of aerospace engineering and operations experience, including 27 years of space launch operations experience. Prior to joining the Company, he was Deputy Director of Kennedy Space Center. His 21 years with NASA in management positions included: Manager of Apollo Spacecraft Operations Division, Director of Expendable Launch Vehicle Operations, and Director of Shuttle Operations for the first four Shuttle missions. Prior experience included five years as Launch Operations Engineer with General Dynamics Corporation and Flight Test Engineer with the Westinghouse Electric Corporation. B.S.A.E., Pennsylvania State University.

Jack W. Pinto, Vice President, Marketing.—Mr. Pinto has 30 years of engineering and marketing aerospace experience and was with IBM Corporation for 23 years. Most recently he served as Director of Marketing, Owego Operations, where he was responsible for $600 million in annual sales for the 5,000-man facility. Having extensive experience working with NASA, the Air Force, and the Navy, Mr. Pinto was manager of the Field Marketing Offices for the Federal Systems Division of IBM. Prior marketing management assignments included Space Programs, NASA Programs, Ship Systems Programs, and Western Region Field Marketing. Program Involvement included Space Shuttle, Space Telescope, HH-60D Avionics and LAMPS integration. He has a B.M.E., Rensselaer Polytechnic Institute.

TCI STATUS

We have negotiated major hardware supplier contracts with McDonnell Douglas, for the core vehicle and systems integration, and with Morton Thiokol, for the Castor solid rocket motor strap-on boosters. We are in the final stages of completing our negotiation with Rockwell Corporation for the 1st state liquid engines. We are working with First Boston Corporation who has agreed to raise the substantial capital required to start and sustain the production activity until cash flow from sales can sustain it. Success in the financial market is heavily dependent on unsubsidized government competition.

In addition to First Boston Corporation's activities, Bank of America has agreed to a $15,000,000 line of credit for TCI against contracts. Bank of America is willing to provide a $35,000,000 customer financing package wherein a credit-worthy customer can finance his launch on a seven year program with payments deferred to the last five years.

TCI strongly believes that full commercial cost recovery is the only economically sound policy for a free market nation to follow. We believe the arguments advanced for continuing less than full cost recovery STS prices are not sound.

SUBCOMMITTEE QUESTIONS

The first question your invitation asked us to address was "what is at stake in the future of space commercialization?"

We at Transpace believe that the direction of the U.S. economy is a central factor at stake. Recent bipartisan effort of the Congress and the Administration has greatly improved our economy by freeing industry of needless and inefficient subsidies and permitting the private sector to compete for market share on the merit of the goods and services it produces. President Reagan's full cost recovery policy for the Shuttle will achieve that same goal for commercial space, resulting in two economic benefits for the commercialization of space. First, purely commercial use of space will become cost-based, permitting efficient deployment of assets and optimal use of this new technology. Second, space transportation will develop rationally responding to market demand rather than government handouts.

Also at stake is an enormous market for a wide variety of products which can be made more perfectly or can only be made in space. These products promise benefits to all mankind. However, we must keep in mind that this activity will not necessarily result in a total addition to current Gross National Product. Some products made in space will simply replace products made on earth. If the products that come out of space are to be a net plus to GNP, their establishment in the market after development is over must be based on covering all costs and an adequate return on investment.

During the research and development phases of new product development, access to space can, and should, be subsidized if necessary. However, when the product enters the market it must stand on its own feet without subsidy of any kind, including access to space. If this does not occur, the nation's resources will be erroneously applied, incentivized by continued subsidy rather than by gains to be made in the free marketplace. Products that depend on a subsidy for their place in the market should be weeded out in favor of those that do not.

If this is done, R&D dollars will be incentivized to flow to development of products which are economically viable and the nation's resources will be used toward building a stronger economy.

Therefore, in addition to increases in GNP from new and better products, also at stake is either the strengthening or weakening of the foundations of our economy. If we encourage the allocation of resources, men, money, materials, toward developing products that participate in the market with all costs covered, plus a rate of return, we will be strengthening the foundation of our economy. On the other hand, if we continue subsidy beyond the research and development stage and into the marektplace, we will be weakening the foundations of our free economy.

Your second question was, "What are the major barriers and issues related to the success of space commercialization?"

A major barrier to space commercialization is incentivizing the capital markets to participate. The capital requirement in the commercialization of space is enormous and will probably be larger than in any other field developed prior to space exploration. In addition, it is riskier, and much greater amounts of capital are required at the head end than in any other field. The capital markets are rightfully skittish in their support of space endeavors. They are getting the wrong signals. Testimony before the House Subcommittee on Space Science and Applications on 21 February 1985 heard five new product entries into space testify that unless government subsidizd access to space was continued after the product had completed its development and had reached the market, that the product could not be viable in the market because its price would be higher than the market would accept. Dependence upon government subsidy for the life of the product will not encourage capital investment without a written guarantee.

During the same hearing, the capital markets also heard the expendable lanuch vehicle industry ask for the elimination of subsidy through the continuation of the government's long standing policy to go to full cost recovery for the Space Shuttle starting in October 1988. As late as May 16, 1983, in his policy on commercialization of Expendable Launch Vehicles the President of the United States reiterated that "It is the U.S. Government's intent to establish a full cost recovery policy for commercial and foreign STS flight operations."

In spite of the fact that the full cost recovery policy for STS is in effect, and was reinforced by the President in the same policy in which he encouraged the start of Expendable Launch Vehicles in the private sector, these committees are holding hearings on whether or not that policy should remain in effect. In this case, the capital markets are getting a strong signal that the government is considering changing the ground rules under which the Expendable Launch Vehicle Industry was encouraged to develop in favor of continued government subsidy for products whose companies claim cannot continue without subsidy.

The present Shuttle subsidy is thus a major barrier to the success of an efficient commercial space transportation industry. Space transportation is a commercial business opportunity that is riskier than many other types of investments. To compensate for this risk, participants in the industry must at present hold out the promise of an attractive rate of return to obtain sufficient capital. However, given subsidized Shuttle competition to transport for-profit commercial payloads, private sector transportation providers will be unable to provide that rate of return.

It was the promise of an attractive rate of return due to full cost recovery for the Shuttle that led to the formation of TCI, excellent people left secure jobs to work for TCI, and substantial amounts of capital were raised and spent. Thus, to remove the barrier, the capital markets must now be assured that the government will not change the ground rules under which the commercial expendable launch vehicle industry was encouraged to develop, in favor of continued government subsidy to companies making the claim that the only way they can survive is with government subsidy.

The third question we were asked to address is "What actions or initiatives are needed to successfully realize the potential benefits of space commercialization?"

For space commercialization to provide long run economic benefits, it must make economic sense or ever greater economic dislocation will occur and the industry will be unable to reach stability. If the product is superior, the marketplace will pay more for it. Wherever management determines that the cost to produce the product will be more than the price the product will bring, managements's responsibilty to its stockholders is to discontinue the development, take its losses, and go on to a project that makes more economic sense. Of course, if the government as a matter of national policy believes that a particular product must be sold at a price below cost to achieve certain societal goals, the product should be directly subsidized. The emerging space transportation industry should not be burdened with a Shuttle subsidy flowing to others. To successfully commercialize space, actions and initiatives must conform to the rules of our free market system.

Government subsidized products in the marketplace make no economic sense, and, in fact, will injure our existing economic structure. In testimony during the House Subcommittee Hearings on 21 February 1985, one company stated that if the $87 Million payload bay price held, only four of the pharmaceutical products being considered by that company for manufacture in space would be profitable. The rest would be weeded out. Putting government subsidized products in the market can only weaken our economy and hurt the taxpayer who must ultimately pay for the government subsidy. In addition, if government subsidized products made in space threaten to replace fully costed products already in existence, will they not also be entitled to a subsidy to survive? The price benefits ratio cannot consistently be distorted and still maintain a healthy economy.

If a product is better, and the added utility is worth it, the market will pay more for it. The extent of the ability of a product to command a higher price is limited only by the measure of its increased utility to the buyer. It has always been the true test of management in the economic world to determine the full costs that must be covered before a product reaches the market, and to determine the price for which the product can be sold in the market. If management has done its job properly, the product will be profitable. If not, the product will suffer losses and fail. At any step in the development process, management must continuously make this assessment.

No promise of continued subsidized government access to space after their products were developed was given to these companies. They testified as much when asked this question by Representative Smith at the House Subcommittee Hearing held on 21 February 1985. They have no right to expect continued subsidy in the marketplace after research and development is completed. Transpace Carriers has the right to expect full cost recovery for Shuttle foreign and commercial launches starting in FY 1989, just as the policy directed when TCI made its decision to enter the market, and indeed, as it continues to direct to this day. A failure to adhere to that policy would result in demands for subsidy from producers of products not currently subsidized but facing the threat of replacement by shuttle subsidized products. National deficits would increase and a tangled web of price support policy would have been established. Thus, sound policy reasons suggest that the subsidy that presently exists should be removed from for-profit commercial products.

Because of the tremendous cost of research and development in space, a straightforward policy of government subsidy for access to space should be developed to encourage development of products of national importance. If the government should determine that a subsidy is necessary in any particular case, the subsidy should be given directly to the user thereby permitting the user to choose the most efficient space transportation mode for its particular product. However, this policy must also provide the clear ground-rule that government subsidy will cease when the product reaches the market. If this is not done, the allocation of resources in our free economy will be distorted and our economic system will be injured.

Until the advent of space commercialization, all activities in space were conducted by the government. As this new economic field is developed, government interaction with commercial entities cannot be avoided and consistency of government action is imperative to the success of commercialization in space. Most importantly, government action and initiatives must be in conformance with the rules of a free market if space commericialization is to result in a net economic benefit for the United States.

In addition to these initiatives, the U.S. Government must stand ready to protect the emerging space industries from foreign government subsidization of their own products in competition with U.S. products in world markets. As other nations fight for their place in space commercialization, the temptation to subsidize will be strong. The U.S. government's intent to combat these efforts, through any economic means available to it, must be clearly stated. Successful resolution of TCI's 301 filing against Arianespace would be a good place to start.

SHUTTLE PRICING POLICY

Before addressing the issue of Shuttle pricing, we wish to state that we find ourselves in a peculiar position. We are staunch proponents of the manned Space Shuttle. Many members of TCI management worked on the program. I was personally involved in the program from 1972 through 1982. I managed the Wasatch Division of Thiokol Corporation from the time it was awarded the Solid Rocket Motor contract in 1974 through the start of its operational phase in 1982. I strongly felt the responsibility for those Solid Rocket Motors at lift-off of STS-1 as I am sure did every other participant in this program which ranks very high among man's accomplishments. I feel some of that responsibility, even today, with each succeeding lift-off. In spite of the tremendous and unsurpassed achievements of the Shuttle to date, we know that it is just the beginning for the Shuttle, as research and development experiments that will benefit the United States and all mankind are proved out and become products for all to use. The full range of human benefits that will most assuredly accrue from the Shuttle cannot be comprehended now, just as it was impossible to fully comprehend the benefits from the discovery of electricity or the airplane in their time.

However, in order to implement the National Policy that is now opening up the gates to commercial activities in space, all participants must compete in an even-handed way for commercial sector payloads. The rational commercialization of space requires NASA to price its services for commercial and foreign users at the same full cost that commercial launch providers must charge. We do not believe that NASA's pricing proposal does so.

Let me begin by explaining TCI's view of this market. There are at least three components to the commercial space industry. The first component consists of payloads that are purely commercial today and intended to be profit-making enterprises. Communication satellites and landsats among others, fall within this category. Second, there are the research and development payloads of commercial users that have no present commercial value but have great commercial potential. The third component of the commercial space industry is space transportation which is growing up to meet the demand of the other two components. Like the airplane, railroad, truck and ocean liner, space transportation is developing to meet the needs created by maturing uses of space.

At present, subsidy runs rife through the entire industry. The Space Shuttle is priced without regard to true full cost of its services. This subsidy may be necessary to encourage the use of space for research and development, and is an investment in our national economic future. However, because there is only one price per Shuttle payload bay subsidized to encourage research and development, this subsidy is also being used by mature for-profit products such as communications satellites which are launched from the Shuttle. Thus the government is subsidizing communications companies and their stockholders at the expense of the American taxpayer.

Moreover, since the subsidy is being provided through the transportation cost of the Space Shuttle, the subsidy has the effect of defeating the development of an efficient space transportation industry as well. The expendable launch vehicle industry cannot compete with a government enterprise that is failing to recover its costs.

FULL COST RECOVERY

The Subcommittee's letter of invitation states among other things that "The subcommittee is examining the Shuttle pricing policy with the understanding that a new pricing policy for the post-Fiscal Year 1988 time frame will be implemented this year" and "the Subcommittee would welcome any recommendations you may have on the most appropriate shuttle pricing policy for the post-Fiscal Year 1988 time frame."

TCI believes that if there is to be a commercial ELV industry in the United States, the only appropriate Shuttle pricing policy is the existing Presidential Policy for Shuttle full cost recovery starting in October 1988 for foreign and domestic for-profit commercial satellite launches. This Policy was rearticulated by the President in his Commercialization of Expendable Launch Vehicles statement in May 1983. (Existing policy allows for lower prices for research and development activities at the same time as for-profit payloads recover full cost).

The Presidential Policy on commercialization of ELV's preceded our agreement by exactly one year—16 May 1983. This Policy specifically addressed the U.S. Government's desire to "ensure a flexible and robust U.S. launch posture to maintain space transportation leadership" and to "encourage the U.S. private sector development of commercial launch operations."

Further, it stated that "the U.S. Government fully endorses and will facilitate the commercialization of U.S. Expendable Launch Vehicles."

Under the section entitled Relationship of STS and Commercial. ELV's the policy stated that "through fiscal year 1988, the price for STS flights will be maintained in accordance with the currently established NASA pricing policies in order to provide market stability and assure fair competition. Beyond this period, it is the U.S. Government's intent to establish a full cost recovery policy for commercial and foreign STS flight operations."

Full cost recovery for STS pricing is certainly consistent with the goals of the overall policy to establish a commercial launch vehicle industry in the United States. It is intended to eliminate the subsidy for mature for-profit commercial payloads, which represent approximately seven percent of NASA's projected Shuttle business for the Fiscal Years 1989, 90, and 91.

A commercial industry cannot exist if it has Government competition that does not face the same economic world. The $87 Million STS price in 1982 dollars recommended by NASA to the President on 17 September 1984, for fiscal year '89, '90, and '91 falls substantially short of full-cost-recovery as the term is known in that economic world and does not assure that for-profit products pay the full cost of their transportation. Indeed, given the apparent NASA definition, no rational businessman would decide to enter the industry.

If it is left to stand, the $87 Million "full-cost-recovery" price for STS recommended by NASA would cause the emerging expendable launch vehicle industry to fail. If TCI were to fail for this reason, the millions of dollars of investor capital that has sustained us thus far would have been lost without the Company ever having had a chance to succeed in the marketplace.

The extent of the deviations from full cost can be demonstrated easily. Please examine the chart we have prepared (Attachment). All of the amounts on the chart are in 1982 dollars and are per unit numbers with the unit being one STS payload bay. We used the data in the NASA recommendation to the President as a baseline and adjusted it for known omissions that could be readily quantified. Column 1 is hardware cost and column 2 is the per unit operations budget. Column 3 is NASA's recommended flight rates per year. Based upon NASA's past accomplishments and facilities limitations, Column 4 is the rate we believe NASA may achieve on the high side. Column 5 is the sum of Columns 1 and 2 and, in the three years bounded by the horizontal lines, is NASA's recommended payload bay calculation for FY '89, '90, and '91 of $83.9, $83.6, and $82.5 Million which the agency adjusted up to an average of $87 Million. Column 6 applies our correction for the lower flight rate which we calculated by taking Column 1 and adding to that the sum of Column 2 times Column 3, divided by Column 4.

Column 7 is orbiter amortization arrived at by assuming a low orbiter cost of $1.5 Billion, divided by the 100 flight design life per orbiter. An interesting sidelight of this is that if we amortize only 3 of the 4 orbiters in 1995, when it is estimated by NASA that the STS will be transitioned to the private sector, there will remain a $2.25 Billion unamortized balance for orbiters alone that would have to be recovered in the commercialization process. Column 8 represents the cost of money computed at 10% per year for 10 years on the cost of 3 orbiters only. Column 9 is orbiter insurance computed at a very low figure of 2% of the replacement value of one orbiter. Column 10 is a correction of Column 1 hardware, labor only, for a more realistic labor learning curve of 93% rather than the 80-88% curves it appears NASA used. Column 11 is the sum of Columns 6 thru 10 which yields an average price of $188 Million per payload bay. The expendable launch vehicle industry would be viable at a $150 Million payload bay price in 1982 dollars. The $188 Million estimate still does not include many items because we had no way of determining the appropriate dollar amount to be added even though these additions would represent substantial costs. It does not include:

Dollars for sustaining R&D or system upgrades,
Offset for taxes which commercial ELV's must pay,
Offset for return on investment which commercial ELV's must earn,
Facility or equipment cost included to make the higher flight rate,
Cost for NASA's commercial marketing effort.

As I am sure the Subcommittee knows, Congress has in the past required government entities such as the Federal Research to include such factors (i.e., in the case of the Federal Reserve, an offset for taxes and an imputed return on investment) when pricing services in competition with the private sector.

In addition to the above, experience indicates that the operations base is over-optimistically calculated. The operations base (Col. 2 times Col. 3) in 1984 totals $1.1B for 8 flights. It is doubtful that the operations base can decrease in 1989 to approximately $.9B (Col. 2 times Col. 3) while tripling the flight rate to 24 launches per year.

If the United States Government is to be in competition with the commercial expendable launch vehicle industry, the United States must charge commercial users all costs that commercial companies must charge. If this is not done, the United States will drive out of business the industry it has encouraged to develop. Certainly, a question to consider is whether or not it is in keeping with the economic objectives of a free economy to have Government compete with private industry at all?

ARIANE AND THE 301 FILING

Another factor in the expendable launch vehicle economic world is the foreign Government competition from the ESA nations' Ariane System, led by the French. This system has maintained a two-tier pricing structure for the same service wherein they charge ESA nations a much higher price than for launches sold in the United States and outside the ESA nations. This has been freely admitted by Mr. F. d'Allest, Chairman of Arianespace, S.A. and Director General of CNES, at the Satellite Summit Conference held at the Watergate Hotel, here in Washington, D.C. on 7 December 1982 when he said,

"(We) asked our European member states in ESA to support Ariane sales during the first three years through a price differential of 25 percent. That means that European payloads are paying during the first three years of the STS pricing policy some 25 percent more than the export sales to help us to balance a bit this subsidy."

The fact that he said, to help balance a bit this subsidy would lead one to believe that the subsidy was much greater than 25 percent.

On February 25, 1982, in a statement before the Senate Subcommittee on Science, Technology and Space, he made much the same statement, putting the blame for the subsidy on NASA. At that time he testified: "When establishing ARIANESPACE we succeeded in convincing ESA and its member States that the STS pricing policy during the first three years of its operations involved a huge subsidy, thus creating an unfair competition. In response it was agreed that for the European payloads launched before mid-1986 the standard price negotiated with ESA and specified in the ESA/ARIANESPACE Convention would include a 25% extra charge to support the company. We consider, and I hope you will consider that these practices are not very sound, as they charge the research and development programs on both sides of the Atlantic, instead of charging the users who reportedly look to gain great financial profit from their commercial applications. We permit ourselves to underline the fact that the orbiters' production costs should also be fully charged to the customers, with the related cost of money. As long as the STS production and operations costs do not reflect realistically the STS pricing policy we shall claim some support through the European payloads launch prices, to ESA and its member States."

We have found that since Transpace Carriers entered the marketplace, Arianespace has been subsidizing prices to an even greater extent. Before TCI, Arianespace charged a subsidized price of about $25 million per Delta class payload outside the ESA nations and about $32 million to the ESA nations. We have now seen prices in the $19-20 million range outside the ESA nations.

On May 25, 1984, we submitted a petition to the United States Trade Representative seeking Presidential action under Section 301 of the Trade Act of 1974 to bring to an end the ESA nations' subsidy of the Ariane system. Our petition was accepted by the Trade Representative on July 9, 1984, and the process is underway. To date, there have been three consultations with the ESA nations who have as a member of their 301 delegation France's Mr. d'Allest. The entire process must be completed on or before July 9, 1985. During these consultations, it is our understanding the ESA nations have reiterated their position that they would like to end their subsidy if NASA would go to a commercial full cost recovery price for the STS proceedings. It is possible that resolution of the issue could come quickly at a price level which would be conducive to U.S. commercial expendable launch vehicle viability if both the Ariane and STS prices could be addressed in the 301 forum.

Such a result would be beneficial to the United States. Atlas-Centaur and Delta Expendable Launch Vehicles would survive in the commercial arena, maintaining for the United States two systems of unparalleled reliability which complement each other. In addition to the commercial market anticipated, these systems could be used by the U.S. to fly government payloads during times of emergency and to alleviate any potential STS schedule problems that might result from increased commercially-oriented research and development payloads of value to the United States and mainkind. It would signal a skeptical financial world that the United States is serious about providing commercial opportunities in space whenever possible. It would maintain, and set the ground work for, expansions and improvements of an established ELV technological base including people, facilities, and hardware, and it would maintain U.S. leadership in space across the broadest front.

We have had many written expressions of support for our 301 petition from members of Congress as well as industry and industry associations.

ALLEGATIONS AND COUNTER ARGUMENTS

Some allege that Delta is old technology. In fact, the U.S. ELVs have been consistently upgraded and enhanced by NASA in order to assure the use of state of the art technology in launch systems and ground systems. This technology and program knowhow have been the reason for Delta's continued, unparalleled success. An outstanding example of Delta contemporary technology is the skin structure which achieves very high structural efficiency resulting in much lower weight than the Ariane ELV. Also, the guidance system is new, highly accurate, and unsurpassed in efficiency and reliability for the launch missions it serves. The engines also are the beneficiaries of not only the man-rated Saturn program and the TITAN program, but also have achieved extensive flights on the Delta and Atlas programs.

It has been alleged that the market is too small to support commercial ELVs and the Space Shuttle. TCI strongly disagrees and believes that the opposite is true. Communications satellite usage worldwide is increasing, providing business opportunities for U.S. ELVs while the Space Shuttle will be the only named reusable launch system to support the Space Station and most of the space industries which the Center for Space Policy quotes as exceeding $60 billion in revenue by the year 2000. TCI estimates the commercial and foreign satellite market for the Delta payload class alone to be on average about 20 per year, not counting the European payloads committed to Ariane.

These numbers are supported by various studies including the Battelle Memorial Institute Outside User's Payload Model prepared annually for NASA. NASA Customer Services, in contrast, has recently stated publicy that the market for domestic and foreign communications satellites will flatten out by the end of this decade to 7 or 8 per year. Yet NASA's planning for 1990 and 1991 indicates that commercial and foreign satellites will occupy the equivalent of 4.2 STS cargo bays. Based on NASA's equivalency factor and planned market share of 75%, this represents a total commercial and foreign market of 28 equivalent Delta class payloads. In a paper presented by Hughes Aircraft to the World Telecommunications Forum in December 1983, it was indicated that there will be 33 foreign national communications satellites alone by October 1987. It was further stated that "The number of national systems is accelerating. They are doing so because they are an economical way to build long distance networks rapidly, both in developing nations and inaccessible regions of advanced nations."

In addition, new international and inter-regional communications will yield greater opportunity for the space launch vehicle industry. Meteorology and remote earth sensing will continue to expand as foreign become more space independent.

It has also been alleged that full cost recovery will result in Ariane capturing the entire marketplace. This assumes that U.S. ELVs will not be competitive on a level playing field which the 301 proceeding is intended to obtain. In addition, Ariane may face operational limitations. Currently the Ariane 4 can only be launched from the second launch pad at Kourou, French Guiana.

With existing facilities, Arianespace claims that 12 per year can be achieved. This is highly doubtful since Delta, with a much smaller vehicle, two launch pads, and 25 years of launch experience reached a maximum of ten per year. Probably a more important factor favoring U.S. ELVs is that their single payload dedicated mission service provides high confidence of full insurability.

In short, Arianespace is incapable of launching the entire commercial and foreign market. The presence of U.S. commercial ELVs in concert with the Space Shuttle will assure that Arianespace will fall far short in achieving the market ascribed to them by those who advance this argument. American industry should not be sold short on its ability to compete effectively with its foreign counterparts if trade is conducted under the rules of the Trade Act of 1974.

Another alleged result of Shuttle full cost recovery is that the high cost of launch will drive users from satellites to fiber optics systems. A recent Intelsat analysis indicates that in this wave of fiber optics popularity, satellites in addition to providing multipoint capability also provide on a per circuit basis a 30 to 70% cost savings compared to fiber optics. If the launch costs, for example, were to be doubled, and amortized over a ten year period, the resultant increase in transponder cost would be less than 10 percent, hardly enough to drive users from communication satellites.

Another argument often heard against full cost recovery is that it will cause potential space technology investors and developers to rethink these investments. TCI believes that R&D in space manufacturing and other commercially-oriented experimentation should have low cost access to space. Mature industries such as space communications should not, and do not, require government subsidy to be profitable. Likewise, when space manufactured products become mature and commercially viable, they too should not require or expext subsidization in any form. The Presidential policy directs full cost recovery for only commercial and foreign STS flight operations and allows for subsidized prices for research and development activities. This was emphasized by the Science Advisor to the President in his October 15, 1984, letter in response to Senator Gorton's letter of August 31, 1984.

One last argument against full cost recovery often advanced is that it would make the upper stages deployed from the Shuttle non-competitive. Upper stages are expendable vehicles used to deliver satellites from the Shuttle's 160 mile orbit to a geostationary orbit 22,300 miles above the earth's equator. With ground launched ELVs, the upper stage is part of the launch vehicle.

There are several upper stages which are either operational or at some stage of development, most of which are cost effective for specific classes of spacecraft. No upper stage, however, should depend on a subsidy of its low earth orbit transportation in order to be economically viable. If such subsidy is allowed, it will place the non-shuttle dependent ELV industry at an unfair competitive position vis-a-vis the Shuttle/expendable upper stage combination. When Ariane and Shuttle price subsidies are removed, charging commercial full cost for Shuttle services would not affect expendable upper stage providers since they would compete on merits and costs of services they provide using the Shuttle priced on a level playing field.

SUMMARY

In summary, Transpace Carriers, Inc. would like to compete in a free market economy consistent with the tradition of this nation. We entered this business relying on the STS going to full cost recovery in FY '89. We believed that the ESA nations were weary of their subsidy and would follow the STS price up. If they did not, we were prepared to file a 301 petition. We filed the petition earlier than we had originally anticipated because they drastically reduced their price coincident with our signed agreement with NASA to transition Delta to the private sector.

The structure of the space launch industry providing transportation to the 22,300 mile transfer orbit now contains: (1) companies which are totally commercial, Transpace Carriers and General Dynamics, who must recover their entire cost plus a return on investment for the entire trip; (2) a quasi-private company, Arianespace, which is 60% owned by France and is subsidized by the ESA member nations; and, (3) private upper stage companies, McDonnell Douglas, Orbital Sciences, and others, which utilize the government subsidized Shuttle for what is essentially the first and second stages of their operation. Government subsidy in any part of this structure distorts the operation of a free economy resulting in a misallocation of resources. These subsidies will ensure the failure of the truly private companies who are not dependent upon government subsidy. Failure to permit an economically sound environment for the commercialization of U.S. ELVs would mean the effective elimination of the two most reliable launch vehicles in the world and the forfeiture of this growing market and technology to foreign interests which are pursuing development and production of ELVs.

On the other hand, successful commercialization of U.S. ELVs can provide the U.S. with a continued leadership position in this segment of space launch services, technical capability will be preserved for the United States, and new ELV innovation will occur stimulated by market demand. Balance of payments will be enhanced, U.S. launch back-up to the STS for ELV-class payloads will remain in place, and emergency systems for many military launches will be available if and when needed. Finally, the financial community, now skittish of capital investment in space will obtain a positive signal from the government's implementation of its stated full cost recovery policy for Shuttle that the U.S. government is serious in its intent to open up space commercially as other opportunities mature.

We seek this Committee's support of the President's policy on full cost recovery. This policy was the major factor for our entry to this business. It existed then and it exists today. All companies entering space commercialization knew of this policy when their decisions were made. TCI relied on it and has every right to expect it will remain in place.

Thank you Mr. Chairman. We will be happy to answer any questions you may have.

Senator GORTON. Thank you, Mr. Savoca.

I will start with Mr. Ferguson and Mr. Hood, and ask you to comment on one of the last subjects Mr. Savoca covered, the likely impact of a multitiered pricing policy with a different price for communications satellites from the lower price charged for space activities or other experimental types of activities based on risk.

Mr. FERGUSON. Mr. Hood may have a slightly different answer, but from our standpoint, that of a company which markets exclusively to satellites that would use upper stages, such a decision would leave us as guests of Ariane Space at launches down in French Guyana. We would not have much of a commercial market left, even under such a multitiered pricing policy.

Senator GORTON. Mr. Hood?

Mr. HOOD. I share that. And just let me say that I made mention earlier about the fact that some of the industry was waiting to see whether or not McDonnell Douglas made any money in the electrophoresis market. We also spent our money on developing the PAM upper stage, as my friend here to the left has done. If that pricing policy is allowed to continue, the way it stands today we will probably lose about $52 million on our investment in PAM. I think that is probably sending the wrong signal to those who are waiting to get into the space commercialization business.

I would just like to make one other point along with that, Mr. Chairman. It was mentioned here earlier about the need to clarify the tax issue, and I would also like to support that position. Also, you were questioning Mr. Gillam this morning about NASA's space commercialization role and the money that they had requested in their current fiscal year budget.

I think if NASA were to back away from that position of requesting—I cannot recall what the line item is now, I think it is about $30 million——

Senator GORTON. $30 million.

Mr. HOOD [continuing]. And choose to put that money someplace else, due to reduced budget constraint, it again would send the wrong signal to those people preparing to come into the space commercialization business. You have got to remember that the people we are trying to attract are nonaerospace companies, and they are not used to doing business in this arena.

The only way we are going to build commercial space business to its potential is to give those people some kind of consistent long-term policy that they can depend on. They have a fiduciary responsibility to their stockholders, as I am sure you recognize, to do the best they can in business planning and in anticipating both the market and the return on their investment, and they cannot do that if these pricing policies and tax policies and commitments by NASA to spend money in this industries vascillates.

Thank you.

Senator GORTON. Dr. Scherer and Mr. Lippy for this next one. Turning back to using the definitions or the phrases which Mr. Hanushek utilized in his CBO report, would you comment on the appropriateness from your perspective and the likely affect of the shuttle pricing policy at the low end of that scale, the so-called short-run marginal costs and/or marginal cost plus some form of capital recovery? What will be the impact if we are at the low end of the scale?

Dr. SCHERER. I think clearly, Mr. Chairman, we would not be in the ELV business. There would be no way of competing, because we are required to make a profit.

Senator GORTON. Are you associating yourself then with Mr. Savoca's point of view that it would need to be even higher than the high end of Mr. Hanushek's definition for the average payload cost of $150 million?

Dr. SCHERER. I think, sir, that that is a little higher than we would consider to be the price at which we could be competitive. We have tried to make a study of that, and it is our conclusion—and this varies a little bit because of the upper stage that might be used in the shuttle when one calculates the price—but it is our opinion that $110 to $120 million is the kind of range at which we could just start to become competitive.

Senator GORTON. Mr. Lippy?

Mr. LIPPY. As I noted in my remarks, yes, there is going to be some short-term market shakeout and there will not be a business for ELV manufacturers, but in our work, we are tasked many times to try and provide an independent perspective, and provide an objective third-party analysis. With that in mind, we have submitted testimony with an eye toward the long-term goals of the country and toward the bigger picture.

Unfortunately, there will be a shakeout from the ELV manufacturing point of view, but a reasonable shuttle price just allows you to do so many things later on that are going to be so important for building our industrial infrastructure for doing the kinds of business we want to do associated with the space station. Jim Samuels is in a better position to comment on this since it is his business, but as people are trying to raise financing and if you are really truly going to involve the nonaerospace community as Bob Hood has pointed out, you have got to give these people an opportunity to get on the shuttle, get manifested, and raise the kind of financing necessary to make a go of it.

Senator GORTON. Would we be better off, or worse off if we were to have a flexible pricing policy and allow NASA to set its prices within certain limits?

Mr. LIPPY. As long as the policy is consistent over a long period of time and people can understand that and they have the assurance of knowing exactly to know what the policy is and know it is not going to change, and as long as the rules are clearly defined, that would be okay.

I would disagree with the two comments here today that the President in his act of last May designated DOT to make the expendable launch vehicle industry happen. I do not think that the President said it is going to happen for sure. He only talked about an enabling act, but it had to be a business decision for TCI and General Dynamics to decide whether or not in fact there was a market there, and could they get into it and make a profit? Our analysis shows, and we have been working on this for a very long time, that they did have a miscalculation in their predictions as to what that market looked like. The satellite communications market is different.

Shearson Lehman/American Express and ourselves have just 2 months ago produced a written report, which we would like to submit for the record [1] that shows what transponder capacity looks like in the outyears, and it is very different from what it looked like when they were considering this as a business decision.

I do not think it is fair to change the rules. I do not think the President said here are the rules. He said I am enabling you to make a go of it; it is your business decision and your judgment as to whether or not there is actually a market. There is not a market presently, and that is why they are asking, in my opinion, for a change in the rules today.

Senator GORTON. Mr. Savoca, it seemed to me you wanted to comment.

Mr. SAVOCA. Yes, I would be very happy to comment on that.

First of all, the Presidential policy of May 16, 1983, did not set the full cost recovery goal for the Shuttle. That policy was set back in 1972 and it has been consistent all the way through NSDD-94, which was May of 1983. Full cost recovery has always been a policy.

When NASA operated the Delta Program, they charged full cost recovery under existing NASA regulations, as I pointed out. I would like to submit copies of the documents setting forth this policy, NASA Policy Directive 8610.5 and NASA Management Instruction 9240.1, for the record.[2]

Then finally, I would like to extend the comment to the marketplace. We do believe that there is a market. We use the market studies that generally are used by all people in this industry. Our market remains at about the same as we always thought it would be, and that is about 30 Delta-class launches a year starting in the late 1980's.

When you talk about business people making decisions on how they go into business, obviously a businessman has to decide what the market is and what he is going to be able to price his product in the market on, and that is precisely what we did. We used the existing full-cost recovery shuttle policy. We projected what that cost would be, and we said there was plenty of room for us to go into business with that policy.

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[1] The report has been retained in the Committee files.

[2] The documents have been retained in the Committee files.

The other companies that are represented here in the materials' processing area cannot count on a continued subsidy for their ride to space. I agree with them that entry rides to space may have to be subsidized, as I pointed out in my testimony, because of the cost and the risk, but in the end result, products that are sold on Earth have to be priced in relationship to the products that are here, not made in space.

Now, people will pay more for products if they are better, but the amount people will pay more for space products depends upon the added utility of that product to the user. And that is a decision that businessmen have to make when they go to start developing a new product. And if they determine that they cannot cover their cost and make a profit against products that are sold in competition, then they have to take their losses and go on to another product.

One of the people here said that when they started there were 11 candidates, and now there are only 4 or 5. Certainly, that happens every day when you decide to develop something. You weed out those that are not going to be profitable, and you proceed with those that are, and you have to depend on covering your cost. Otherwise, the product will fail.

Senator GORTON. Mr. Samuels and Mr. Ferguson—Mr. Samuels first—is there simply going to be an inverse relationship between shuttle pricing policy and the number of dollars spent in commercial space development? That is, will the amount of development slide upward as the NASA pricing policy slides downward? If we want $50 billion in revenues from commercial space development, what kind of pricing policy do we need to establish?

Mr. SAMUELS. Depending on your definition of commercial activities, if you include communications satellites that would be one answer. If you were looking at materials' processing and electrophoresis and things of this nature which require the use of the shuttle and cannot be performed on expendable launch vehicles, then I think you get a somewhat different answer. And in that instance, if you include the latter category, then I think that you would in fact have an inverse relationship.

Senator GORTON. Mr. Ferguson?

Mr. FERGUSON. I regard the shuttle as being America's railroad into space. It is a resource that helps to provide for the development of a whole new series of industries. If we price that resource higher, by the laws of economics there is going to be less utilization of that resource. So, I would say there is a direct correlation between use of the railroad and the price we charge users of that railroad.

Senator GORTON. Mr. Samuels, back to you. How would potential investors react to shuttle pricing policies which exceeded $100 million?

Mr. SAMUELS. To the extent that they perceive that the availability of the shuttle for materials' processing and electrophoresis type experiments and other types of businesses that were dependent upon the availability of the shuttle would determine their reaction to that. To the extent that they felt that that jeopardized the availability of the shuttle, I think they would view that perhaps negatively.

Senator GORTON. Mr. Lippy, I would like your comment on that question. How much would that delay the development of the commercial space endeavor, space processing and the like, the $100 million price?

Mr. LIPPY. Well, again we have just completed a very extensive and in-depth analysis internally looking at the various categories of commercial development, and I would like again to submit that as part of the record for you to view it more in depth.

It would have, in my opinion, an adverse effect. The higher the price, the less chance I think there is for capital to be raised for projects, and certain kinds of projects are going to be squeezed out of the marketplace.

Senator GORTON. Senator Rockefeller?

Senator ROCKEFELLER. I agree with what Mr. Lippy said about the need of keeping our technological advantage. There is something about making this work which is not only incrementally important to the Nation in terms of what we learn and what new technologies we arrive at, but there is also something quite frankly psychologically very important about it, too.

However, one homily. I remember after the OPEC embargo of 1973 that the coal industry went wild and overbuilt to an extent seldom practiced by major industry, albeit that being an energy industry. And after a period—they had enormous expectations. I do not know what their market research was, but I suspect that whatever it was, it was wholly inadequate, because it misled them greviously. And as a result, the history of Appalachia at least has been the shutting down of coal mines starting approximately in 1978, and thousands thrown out of work.

Now, I have often asked myself what was it that these captains of the coal industry—what did they tell themselves? What data did they depend upon to make judgments to invest millions, hundreds of millions of dollars into the sinking of mine shafts for a product which was probably predictably going to have trouble?

The parallel is not entirely fair, but it is the only one I could think of. What is the nature of your market research? Marketing research for coal, utilities, metalurgical uses, exporting appears somewhat more predictable than the innovative technology that you are into. How do you do your market research? And how old is your market research data?

You mentioned, Mr. Savoca, that your data is current; it is what we use; it is standard market research. Neilson uses market research. It is inaccurate in that it only measures a half-hour. It does not measure minute by minute, and is increasingly less useful. It is the standard; but it is not accurate in my judgment.

How do you measure what it is that you need to be doing and what the marketplace is going to call for? And how can you build accuracy as you approach the Congress and others for incentives, public dollars, or whatever, price levels? How can you make those determinations with any degree of accuracy?

Mr. Savoca. Are you asking me, Senator Rockefeller?

Senator Rockefeller. Yes.

Mr. Savoca. Well, let me agree with you that all market research has some degree of risk in it, but every industry has to put their dollars on what they believe the market is, as you well know. Now, we have used the great body of information that is available in the market. It is the same marketing basic study that NASA uses and commissions every single year, and it is based on the Battelle study, which is updated every single year.

Up until the shuttle price became an issue and heated up, so to speak, 2 or 3 months ago, everyone in the market generally agreed with the market as it is. And if you take a look at the price that NASA is recommending at $87 million, they say that they are going to have 4.2 payload bays in 1990 and 1991 each dedicated to expendable—dedicated to commercial satellite-type launches, and 2 in 1989.

Now, when they do their market study, those numbers agree with what we say the market is, even though there is now a difference of opinion because of the shuttle pricing issue. So, if you equate those payload bays to Delta payloads, NASA is saying—and you put their 75 percent capture factor on it—NASA is really saying that they agreed to a 28-per-year market for those types of launches.

NASA's own transponder study completed in November 1984 continues to say that it is a growing market. Hughes' paper delivered at the end of 1983 says that the foreign satellite market is rapidly increasing. There's a large backlog of applications, of applications, that cover about 85 spacecraft. The spacing for satellites has doubled, and the technology, the antenna technology, continues to improve and outpaces the ability of putting spacecraft up. So, there is going to be plenty of spaces up there.

Senator Rockefeller. Can I interrupt for a second, Mr. Chairman, simply to say I am troubled by two things. One, I am informed that Battelle studies have been off by a factor of 50 percent only very recently, No. 1.

No. 2, you say NASA does these things. Would not different private enterprises, if this is in sort of the spirit of American enterprise, I mean is not the way you break through and accurately measure when you have one market research mode competing against another one, and that your company and the other company are hard at it trying to outdo each other, and that therefore the people who do the research have to refine their data because it is not for the whole world, it is for you and it better be better or else you are going to go get somebody else?

Mr. Savoca. That is normally the way it is done, but in this case there is no expendable launch vehicle industry. We are at the point of starting. So, there are no competing industries.

Senator Rockefeller. Well, then I have to come back and say how accurate is it? If it is off by a factor of 50 percent let us say in a recent year, then what is the meaning of it? If there is no industry, or if it is just starting up, then is it that sacred? Therefore, is it that reliable in terms of 24 launches a year, or whatever would pertain to ELVs?

Mr. **Savoca**. We believe that it is consistently reliable. There has been in just very recent years, there has been a slowdown. But the spacecraft are being built. They are getting in place and they will be flown.

Senator **Rockefeller**. Mr. Chairman, Mr. Lippy is going to have a coronary arrest if he is not allowed to say something.

Senator **Gorton**. By all means, go ahead, Mr. Lippy.

Mr. **Lippy**. I disagree with a number of points. The fact of the matter is, Senator Rockefeller, that you are absolutely correct when you were talking about the lack of consistently reliable data. Battelle is one example. The second example would be a November 1984 study by NASA. And as I just pointed out, there is a study that we did recently on looking at transponder capacity, and Mr. Samuels headed up that study and he can tell you more about it.

We are finding that there is a technology shakeout going on. We are finding that the whole marketplace is basically in a state of flux. Now, we have spent a lot of time reviewing in our market projections of last year, showing that we thought it would be about $65 billion by the year 2000. We have reduced that by 20 percent, part of it because of the IOC slip on space station, but also part of it because we have spent almost a year evaluating all of the previous studies that were done. And as you know, as you have pointed out several times, doing projections out to the year 2000 is a very risky business for a number of different factors.

My only point is the one I made in my statement that, as a business decision, looking at those kinds of factors, there is somewhat of a risk involved. I think that TCI is asking for a change in the rules. I do not think that the market studies that they have based their business on are all that accurate. As you pointed out, NASA when it is putting together its figures, they do not reevaluate the techniques that they use to do their projections. They do not go back and always speak to every manufacturer. They do not go back and evaluate all the technologies. They, basically, update the study.

Well, we have gone back and not just updated, but we have examined the techniques and the processes that were used initially to come up with the projections, and we find that they are fairly far off the mark in a lot of cases.

Mr. **Savoca**. I would like to say one thing for the record. We are not asking for a change in the rules. We are the only company represented here at this table, other than General Dynamics, that is asking for a continuation of the rules.

Mr. **Ferguson**. I would just like to comment on that very briefly to say that, although full cost recovery has been part of the Nation's policy for some period of time, I do not think you can draw a conclusion that full cost pricing is necessarily the way to achieve that goal.

Senator **Rockefeller**. He is the chairman. Do not look at me.

Senator **Gorton**. Do you have any more questions?

Senator **Rockefeller**. No, I do not, but they have some more statements they want to make.

Senator **Gorton**. Dr. Scherer?

Dr. **Scherer**. Yes, sir. I wonder if I might try to boil this down to one simple type of question that you all should consider. I think the basic question is: Should there be price supports for the commercial satellite industry who have had a quite lucrative market for a number of years (the older companies have)? If you have full cost recovery for those sorts of folks, then the ELV's can compete if there are no price supports for them.

The other subject of the emerging industries—we fully support subsidizing them as necessary to bring this industry into being. But basically giving price supports to the commercial satellite industries is the key question here.

Senator **GORTON**. Mr. Hood?

Mr. **HOOD**. I think there is one other question here, Mr. Chairman. You are dealing with three parts to this equation. You are dealing with the expendables in this country, and you are dealing with the shuttle pricing policy in this country, and I think on both of these issues the committee is very capable of making some decisions.

But the third is Ariane. What are you going to do about that? As long as we allow Ariane, with its subsidized price to have its way, I really do not think any change in shuttle pricing policy, unless you drive it down to some ridiculously low number, is going to keep Ariane from selling their services and taking business out of this country.

I can remember when we were still manufacturing the Delta launch vehicle, one of the Delta launches that we lost to Ariane was well under $30 million. It was down in the $20-million range. So they are quite capable and willing to support that price to whatever it takes.

Now I think an increase in the shuttle price is only going to allow an increase in the Ariane price and a reduction in their subsidies. The member nations that are currently subsidizing that price are going to feel a lot better about it if the shuttle price goes up, allowing them to reduce their financial support.

Senator **GORTON**. Are those subsidizing nations uncomfortable with that?

Mr. **HOOD**. I believe they are, sir.

Senator **GORTON**. One last comment, Mr. Savoca.

Mr. **SAVOCA**. I would like to comment on the Ariane situation. We, as you know, have filed a 301 action with the U.S. Trade Representative against Ariane. That action is being pursued today, and if it goes its full course it will have to be completed by July of this year. The Trade representative has told us that their recommendation will be in prior to July of this year.

The U.S. Government then within the 301 procedure, has the ability to have Ariane toe the line in this area, and the issue with respect to Ariane can actually be resolved in one setting. That is, if we were inclined to have the NASA price for commercial and foreign satellite launches be entered into the negotiation within the 301 filing, we could actually get an equalization of those two prices with the understanding that if the ESA nations did not live up to their part of the agreement, that there would be certain sanctions maybe even to the extent that NASA would price their launches at zero, if that happens. So there is a policing action available. There is an inclination on the ESA nations' part, by request, to include this pricing aspect in the 301 filing, and it can be resolved that way.

Senator GORTON. Thank you all very much. You have helped us a tremendous amount in these difficult decisions we have to face.

We do have additional questions which we will submit in writing, and some of the other Senators have questions.

[Whereupon, at 12 noon, the hearing was adjourned.]

NASA AUTHORIZATION FOR FISCAL YEAR 1986

THURSDAY, MARCH 28, 1985

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:30 a.m., in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to this third of a series of hearings of the Subcommittee on Science, Technology, and Space on the fiscal year 1986 NASA authorization. Today's hearing will focus on NASA's Office of Space Science and Applications, authorizations for these programs, and the direction of our Nation's science and applications endeavors.

The 15-percent growth in NASA's Space Science and Applications budget request above the fiscal year 1985 funding level is encouraging in that it reflects the commitment by NASA to maintain a vigorous science and applications effort relative to the total NASA budget.

This Space Science and Applications budget request strongly supports NASA's ongoing programs such as the space telescope, the Galileo, and the Ulysses planetary missions, and the ASTRO-1 observations of Halley's Comet, each of which are scheduled for a fiscal year 1986 launch.

While the present budget climate and the budget deficits have made us all more conscious of our priorities, I note with concern the omission of any new starts from NASA's Space Science and Applications budget request. While this omission may reduce the strain on the present budget request, it also creates an undesirable and difficult situation for fiscal year 1987 when a total of four to six programs will be seeking a new start approval.

The programs that are not approved in fiscal year 1986 will have to wait yet another year for a new start, and may be adversely affected as a result of this delay. Not only could a delay affect the scientific returns of some of these programs, but it could also jeopardize the international framework within which some of these programs are structured.

In the end, this could be more costly to NASA and could cause even greater budgetary problems in later years. I hope that during this authorization process, steps can be taken within the boundaries of fiscal responsibility and scientific balance to create and maintain a logical and orderly progression of new science and applications programs.

Today we will examine other issues that are equally important to the future of our science and applications endeavors, such as the frequency that science and techology experiments fly on the shuttle, NASA's role in remote sensing research and development, and the mix of our scientific disciplines with NASA's Space Science and Applications budget.

We all know the importance of the science and applications undertakings. They widen our scientific vista from what is normally a very restricted field of view here on Earth, and they satisfy the visionary and exploratory needs of the human race. Without a carefully conceived long-term strategy, however, the answers that we seek may not be discovered. We, as a great society, cannot afford to miss these opportunities.

It is from this frame of reference that we look to the testimonies of our distinguished witnesses to provide insight into the problems before us and to the possible solutions. Our first witness is Dr. Burt Edelson, NASA's Associate Administrator for Space Science and Applications.

Senator Riegle, do you have an opening statement?

OPENING STATEMENT BY SENATOR RIEGLE

Senator **Riegle**. Mr. Chairman, this is the second day of hearings into NASA's programs, operations and future plans. Today we will review the Space Science and Application Programs, which are perhaps the most exciting aspects of NASA's work. It is the Space Sciences Program that has taken mankind to the farthest reaches of the universe, and has captured the imagination of millions of people throughout the world.

Meanwhile, the Space Applications Program is responsible for technological developments in communications satellites, which is a $3 billion industry in this country; remote sensing and materials processing, all of which have created countless jobs, new industries, and new opportunities.

The Space Sciences and Applications Programs are of great importance and benefit to universities and industries in Michigan and throughout the Nation. Furthermore, I have always considered myself a supporter of these programs within NASA. Despite this, I am concerned about the justification for the proposed increases in these areas. We have just completed an arduous budget committee process, as the chairman knows, and very few programs or functions received increases in spending; especially increases of this magnitude. I am hopeful that the witnesses today can provide the evidence and justification for these increases.

As you know Mr. Chairman, at our hearing last week, I expressed some interest in the National Science Foundation Engineering Programs, and their role in enhancing our competitive position in world markets. There is much agreement, as evidenced by the Young Commission report, that the United States has fallen far behind many other nations in its science and engineering infrastructure in the universities. It is critically important that we make every effort possible to devote resources to the goal of making our country preeminent in all facets of engineering.

Dr. Bloch, Director of NSF indicated in his testimony that a major need exists in the area of instrumentation for the support university research and engineering programs. I am pleased to note that NASA has committed some of its fiscal year 1985 and 1986 funds to assist universities in this area. I feel strongly that we need more cooperation of this type.

Mr. Chairman, I view the Space Science and Applications Program as an indication of our scientific and technical abilities. There is much to be proud of in this area, and also some which causes concern and I look forward to working with you, Mr. Chairman, and with NASA to craft a balanced program that will strengthen our Nation's technical and scientific base.

Senator Hollings has an opening statement which he has asked be included in the record.

[The statement follows:]

OPENING STATEMENT BY SENATOR HOLLINGS

Mr. Chairman, during the late 1960's, a popular phrase on college campuses was "a man's reach should far exceed his grasp." I'm not really sure who coined the expression, but I am sure that the Office of Space Science and Applications gives it new meaning.

Mr. Chairman, as you know, I'm just a country lawyer like yourself who can't help but be amazed when I see how far the nation's civilian space program has gone in less than 30 years. I realize that astronomers have long gazed at the stars and planets, but now we are developing the capability to visit and probe these once far distant wonders. Where will it end? No one knows.

In its fiscal year 1986 budget for space science and applications, NASA continues to point us in the direction of new challenges in materials processing, communications, and remote sensing, as well as space exploration. In fiscal year 1986 NASA will launch the Galileo Mission that will fly by Jupiter, the Ulysses Mission that will offer the first ever view of the sun and solar system from above, and the Hubble Space Telescope that will revolutionize our view of the universe in a manner as dramatic as Galileo's discovery 350 years ago. In addition, Voyager will continue its journey and finally encounter Uranus. About the only thing NASA lacks in fiscal year 1986 is a significant Halley's Comet Mission, and that is unfortunate.

On that thought, Halley's comet offers us a shining example of how far Western Civilization has progressed in the arena of space science and applications. Just listen to how the comet was received by the inhabitants of our plant during some of its previous visits to our galaxy:

1066—Astonomers warned King Harold II that the comet boded ill for his hold on the crown. Not surprisingly, he was defeated at Hastings by William of Normandy.

1456—The Turks seized Constantinople and the Pope called the comet "a symbol of the anger of God" and ordered a short prayer—"Lord save us from the Devil, the Turk, and the Comet."

1908—News that the planet Earth would pass through Halley's tail set off genuine panic in some quarters. The New York Times trumpeted in a headline, "Chicago is Terrified! Women Are Stopping Up Doors to Keep Out Poisonous Gas."

1985—Today's headlines read "Get Out Your Telescopes, Halley's Comet is on the Way Back."

Without a doubt, our reach is continuing to exceed our grasp. But as we will hear today, tomorrow represents new challenges that require policy decisions today.

We are entering the eras of space commercialization, the space station, and international cooperation. We are expanding our reach, and we are realizing the never-ending challenges. Whereas in the past we talked of planetary probes, we now talk of manned missions to Mars. Whereas in the Apollo Program our challenge was to reach the moon, our challenge now is to settle on the moon. Whereas in the past our objective was to get into outer space, we now talk in terms of establishing a permanent presence in space.

Mr. Chairman, it is quite clear to me that future generations will look upon us much the same way that we now view our ancestors—"oh, how primitive their knowledge of the universe was." Yet, when they do pass this judgment, I hope they will be able to realize, as we do of our forefathers, that our dreams helped us to extend our grasp.

Mr. Chairman, I look forward to the testimony of our distinguished witnesses. I also hope they will present the type of compelling testimony that helps us fund these space science and applications initiatives that turn science fiction into science fact.

Senator GORTON. We would be delighted to hear from you, Dr. Edelson, and to have you introduce those whom you have brought with you. Obviously, we will include your entire detailed statement in the record, and would appreciate summary of it at this point.

STATEMENT OF DR. BURTON I. EDELSON, ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY DR. JEFF ROSENDAHL, ASSISTANT ASSOCIATE ADMINISTRATOR FOR SCIENCE; AND RON KONKEL, DIRECTOR OF RESEARCH AND ADMINISTRATION DIVISION

Dr. EDELSON. Thank you, Mr. Chairman. It is a pleasure to be here this morning to present the fiscal year 1986 budget request for the Space Science and Applications Program.

I have here with me this morning, Mr. Chairman, on my left, Dr. Jeff Rosendahl who is Assistant Associate Administrator for Science; and on my right, Ron Konkel who is Director of Administration and Resources Management Division.

The Space Science and Applications Program is a vital and exciting one, a major part of the Nation's space program. It involves many scientific disciplines and has several distinct but related goals: to create new scientific knowledge; to develop new technologies and capabilities; and to apply these technologies and capabilities for the benefit of this country and for all mankind.

The fiscal year 1986 budget will support a healthy, active and balanced program. It will continue the all-important research program; move forward on previously approved flight missions; continue our planning in advanced technology and development efforts; and support our active involvement in the space station program.

This budget represents a commitment to maintain U.S. leadership in space science and in the practical applications of space technology and systems. We will retain the U.S. leadership in these areas that we have enjoyed over the past 25 years.

Let me review quickly several of the more noteworthy successes of the past year. These include the repair of the Solar Maximum Mission spacecraft in April 1984; the successful launch of the International Active Magnetospheric Particle Tracer Explorer [AMPTE] in August 1984; launch of the second in a series of Earth observation payloads on the space shuttle in October; the first launch from the shuttle of a scientific spacecraft, the Earth Radiation Budget Satellite [ERBS], also in October.

Time does not permit a detailed discussion of these achievements. However, as examples, I invite your attention to the several posters on both sides of the room which we have positioned to show results from the Earth observation payloads flown on the shuttle in October 1984.

Our past achievements are prolog for the future. I anticipate great things in Space Science and Applications during the coming year. I would like to touch now on several points that are basic to our program and critical to an understanding of how we conduct it.

We spend a great deal of time trying to develop the program balance needed to ensure a scientifically successful present and a healthy future. To this end, we have endeavored to support a flight program that will yield excellent results and, at the same time, give the Nation the best return for the dollars expended.

We have a carefully considered flight program that is based on the very best advice available in and out of government. However, we are also sensitive to the need to maintain the lifeblood of the program—the people and institutions supported by research and analysis activities. I am happy to report that we are doing well in both areas.

Let me give you some examples:

We recognize that a vital Research and Analysis Program is critical to our future success and have made a special effort to ensure that R&A is adequately funded. I believe that the R&A program in fiscal year 1986 demonstrates our commitment and concern. I would like to point out that the R&A budget of $230 million, up 8 percent in this request, ensures continued support of university investigators and provides significant amounts of instrumentation for university laboratories.

Funding for Microgravity Sciences and Applications, a new field, has increased significantly in this budget from $27 million to $34 million, up 25 percent. Our program scope has been broadened with two primary goals: to use the microgravity environment of space to gain a better understanding of the physics, chemistry, and material science involved; and to make the results of this basic research available to support practical applications.

We continue to work with private industry through joint endeavor agreements to promote commercialization, and we are establishing two centers of excellence in pharmaceutical research and organic separations—one at the University of Arizona, the other at the University Science Center in Philadelphia.

Life sciences funding is up substantially. This will support the increased activity related to space shuttle operations and to the space station. The Life Sciences Program provides a scientific, medical, and biotechnical base needed to ensure safe and productive manned space flight activities. We also seek to advance our understanding of space-related biological processes.

My office is directly involved in planning for the space station. We have conducted a number of studies of how various science and applications activities could be enhanced for utilization of the manned space station and its associated unmanned platforms.

We have developed a mission plan for initial operation of the space station in the years 1992 to 1994. This plan places high priority requirements on the manned station for primary servicing and repair capabilities to co-orbiting scientific spacecraft, and to conduct microgravity and life sciences experiments; a high priority is also on polar platforms for earth observations.

We have established a task force in the scientific use of the space station under the chairmanship of Prof. Peter Banks of Stanford

University. This task force is serving as the focal point for the scientific community to provide advice on how space station capabilities may be utilized to support science and applications activities.

Over the next few years, we will develop instruments for both the manned space station and its unmanned platforms and orient our shuttle experiments, wherever possible, to provide a smooth transition from shuttle to the space station era.

International cooperation is critical to the long-term health of the Space Science and Applications Program. Some excellent examples of recent successes include spacelab–1, the infrared astronomy satellite [IRAS], and the active magnetospheric particle tracer explorer, AMPTE. Our future plans include many opportunities for international participation and cooperation.

Our Space Science and Applications Program is increasing in depth, scope and intensity of effort. We will witness a spectacular year in 1986, including some of the most advanced and potentially rewarding scientific missions ever attempted:

THE VOYAGER URANUS ENCOUNTER

In early 1986, the Voyager spacecraft will encounter the planet Uranus, to give us the first close-up look of that distant, unusual and unexplored planet. It will then continue on its way to Neptune.

ASTRO-HALLEY

Also early in 1986, a special set of three ultraviolet telescopes, known as the ASTRO payload, will fly aboard the space shuttle to make observations of Halley's Comet.

We will launch the Galileo mission to Jupiter in May of 1986 to conduct a comprehensive exploration of the giant planet, its atmosphere, magnetosphere, and satellites. It will use both remote sensing instruments and an atmospheric probe.

Ulysses, formerly known as ISPM, a joint program between NASA and the European space agency, will be launched into a trajectory out of the plane of the ecliptic to obtain the first view of the Sun and solar system looking down on the solar polar regions.

The Hubble Space Telescope, the centerpiece of our scientific program, will be launched on the space shuttle to gain a vast improvement in our ability to observe and explore much of our universe unreachable with ground based telescopes.

Also in 1986, we expect to fly SLS–1, the first dedicated spacelab for life sciences on the space shuttle to study biological processes in the microgravity environment and to help us learn more about long-time stay in orbit.

By any measure, 1986 should be a banner year for the Space Science and Applications Program.

These achievements will be a direct result of the carefully planned Space Science and Applications Program of past years that is continued with this request.

Our budget request, Mr. Chairman, for space science and applications for 1986 is $1,613.2 million. The space applications portion of this request is $551.8 million. The details of the budget request are included in my written statement and a summary is attached to this overview.

Mr. Chairman, that concludes my statement. I will be happy, as will my colleagues, to answer any questions that you may have.

Senator **Gorton**. Dr. Edelson, how banner a year will 1986 be if Congress puts a freeze on the NASA budget?

Dr. **Edelson**. That would, I am afraid, Mr. Chairman, cause serious harm to my program. It would mean something in excess of $200 million cut into our program and would seriously——

Senator **Gorton**. What in turn would that mean? How would you prioritize that?

Dr. **Edelson**. We simply would not be able to carry on the program at the pace we have it planned. It would be possible to take only minor cuts in ongoing programs which are getting close to launch, and therefore any cuts of that magnitude would have to be absorbed by either eliminating or seriously delaying programs.

Senator **Gorton**. Which would be more likely—an elimination of some and protection of others, or a scaleback of all of them proportionately?

Dr. **Edelson**. I believe that either elimination or a delay of as long as a year in major programs, would be the only way that we could sustain a cut of as much as $200 million.

Senator **Gorton**. Let's go back to the recommendation which the administration made. As you know, NASA was treated as generously or more generously than just about any other program in the entire Federal array by the administration's budget request. And yet you did not propose a single new start for fiscal year 1986, thus creating a huge backlog.

Given the rather substantial increases, what kind of priorities cause these very substantial hikes in many existing programs while, in the other hand, there are no new starts at all?

Dr. **Edelson**. We are sorry, Mr. Chairman, that we do not have new starts this year. It would, of course, be nice to have one or two. But, we feel that a 1-year hiatus in new starts would not be harmful to the program.

We do have a generous budget request for fiscal year 1986. It has allowed us to increase and augment our work in a number of fields. I would mention first our Research and Analysis Program, the lifeblood of our program, which provides the ability to analyze the results of past missions and provides seed corn for future missions.

We have been able to step up the work in microgravity science by 25 percent and in the life science flight projects by a significant amount. We have been able to include the capability to keep the Voyager Program going for an opportunity to observe the planet Neptune, and we have provided funding for computer processing support for many projects for the development of pilot data systems and in many other areas to gain a really healthy, supporting research program to our flight missions.

Senator **Gorton**. And those all had higher priorities than any of the new starts?

Dr. **Edelson**. I think the way I would choose to answer that question, Mr. Chairman, is that the continued support of our research base is absolutely essential for continuity, whereas getting any particular new start does not affect the overall health of the program.

So to that extent, obtaining a healthy research base is more important than any particular new start. I would conclude that point by saying we are happy with the balanced program that we feel we now have. And we do look forward to getting some of these flight projects started in fiscal year 1987.

Senator **Gorton**. According to a recent article in the Space Commerce Bulletin, you stated that the highest priority mission of the space station is servicing and repairing the space telescope, and the deployment of the polar orbiting platform will be the No. two priority.

Does this represent a NASA position, and how did you come to those priorities?

Dr. **Edelson**. That represents a position of my office, Mr. Chairman. Since our office is responsible for setting priorities for science and applications, it does I believe represent an agency position. However, it has not been formally adopted as such.

I think I can most quickly justify that by pointing out that servicing or repair and maintenance in orbit is our first priority because it is necessary, it is essential to sustain ongoing projects, specifically the Hubble Space Telescope and the Gamma Ray Observatory which are designed and are being built and will be flown, depending upon servicing in orbit. The Hubble Telescope, which is the centerpiece and most important scientific program that we are working on at the present time, is built to be a long-lived, relatively permanent observatory in space. It has a number of instruments on it which may be changed as new instruments are developed and as the scientific data is evaluated and as technology advances.

It is also built in such a way that should there be failures in any of the spacecraft systems or the instruments or the fine guidance sensors, they can be replaced. Some of these replacements would be difficult to sustain from the space shuttle because it simply does not have a long enough stay time in orbit, and would have to be configured specifically for this mission. We thought originally that it might be possible to repair and service the Hubble Telescope on the ground, and that if there were a failure or a desire to replace it, we would go up, capture it, take the space telescope back to the factory and fix it up. When we studied and evaluated technical difficulty, the time it would take and the enormous cost involved, we realized that was not a feasible way of doing it.

So now, Mr. Chairman, this is a rather lengthy answer, we are absolutely counting on the space station to be able to service and repair the Hubble Space Telescope, the Gamma Ray Observatory as well, and we are planning for follow-on observatories, the advanced x-ray astronomical facility and the infrared telescope of the future to be serviceable by that space station.

As to the No. two priority, the polar platform, really antedated—the concept of an orbiting polar platform for earth observation antedated the Space Station Program. There is a very widespread support from the research community. Also, we have undertaken an agreement with NOAA that the polar platforms will be used for operational purposes, and so development of the polar platform is our No. two priority.

Senator **Gorton**. In testimony which was submitted to the subcommittee, Dr. Banks of NASA's task force on scientific use of the space station, stated that the needs of science will be better met by the introduction of smaller, co-orbiting, free-flying modular satellites, rather than by a single larger, co-orbiting satellite.

Can you give us your current views on this subject and tell us why NASA earlier advocated the larger single co-orbiting platform?

Dr. EDELSON. Yes, Mr. Chairman. That is a subject which is under intense study. The concept of the co-orbiting platform which would be characterized by having either a single large instrument or multiple small instruments and payloads on board, which would have spacecraft systems which involve commonality with polar platform and with the space station itself—I am talking now about communications, stabilization, solar power and so on—and which would be serviceable and repairable by the space station in the same orbital plane is a concept that is very attractive and has several possible uses.

It might be used for astrophysics, it might be used for space plasma physics, it might be used for materials processing in space. And there are advocates of each of these uses in the scientific community and members of those various communities are on Peter Banks' task force.

His report accurately reflects the views of some people. Let me say that one of the purposes of the phase B studies that we are now entering into on the space station platform is to consider various designs and configurations of the co-orbiting platform and try to see how best missions that we are planning for science and applications can best be accommodated on co-orbiting platforms.

And it may be large or small and have many instruments, or only a few. And that is yet to be determined.

Senator GORTON. This question, in a sense, is the other side of the coin from my earlier question on new starts.

But a number of advisory committees have questioned the level of the funding for the research and analysis programs as compared with funding for scientific flight programs. Can you tell me what you are doing to respond to those recommendations and whether or not you agree with the committee report that states that inadequate funding in some but not all of the disciplines is the most pressing problem in the R&A Program?

Dr. EDELSON. Yes. I would like to ask Dr. Rosendahl to address that question.

I would only say as a lead-in, that we have paid a great deal of attention to that very question. We have had our advisory committee, SESAC, the Space and Earth Science Advisory Committee, address that question. Dr. Rosendahl worked with that committee and a special task force set up to explore that, and is very competent to give a good answer on that.

Senator GORTON. Fine. We will hear from Dr. Rosendahl.

Dr. ROSENDAHL. Yes. Of course, the comment you made is a direct quote from the report of the Space and Earth Science Advisory Committee which looked very intensively over a 1-year period at the health of the R&A Program.

I think we would, in fact, agree with the report. We discussed it extensively with the Space and Earth Science Advisory Committee at the time they brought this recommendation in at the end of last

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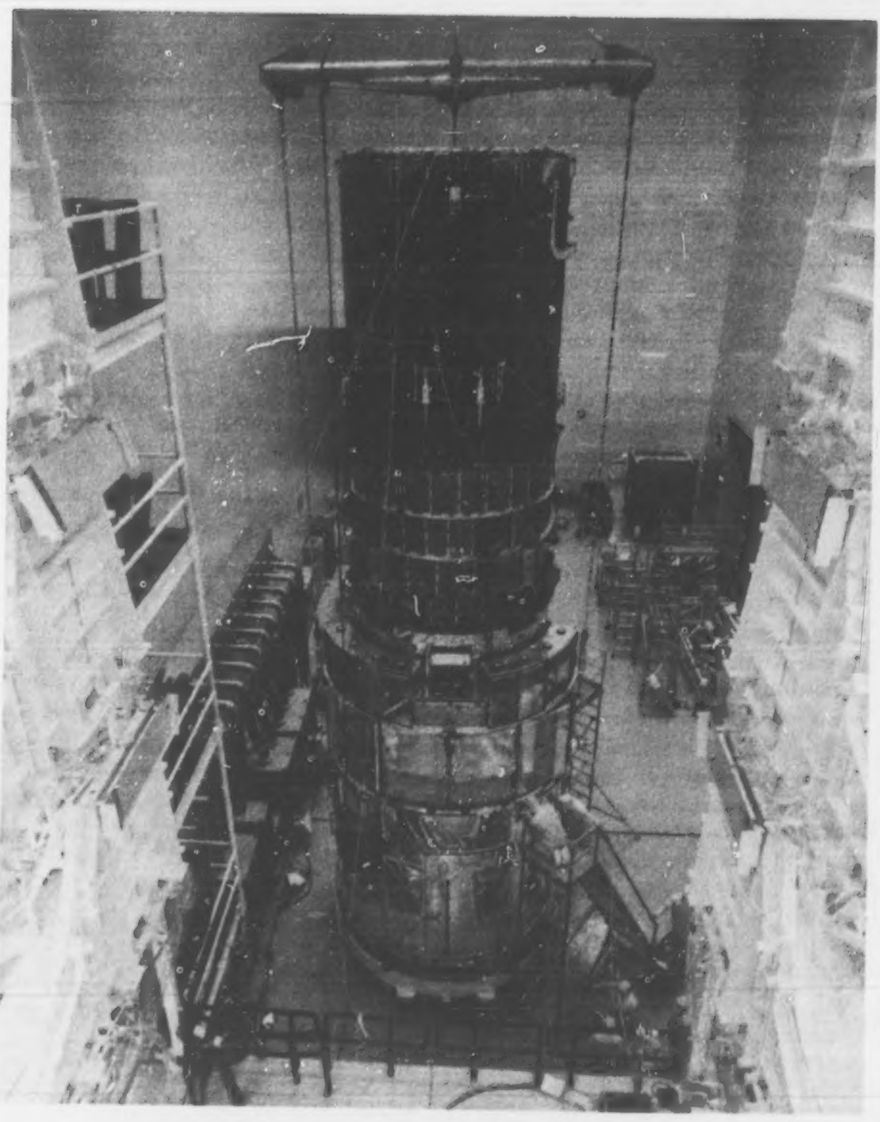


FIGURE 1.—Hubble Space Telescope assembled at test facility, Lockheed Missile & Space Co.

Senator GORTON. I have really covered barely half the questions I have for you, but at this point we do want to hear from the other panel. We will submit the rest of them in writing, and Senator Riegle's questions.

Senator Rockefeller.

Senator ROCKEFELLER. Nothing, thank you.

Senator GORTON. Thank you all very, very much. You have been a big help.

Dr. EDELSON. Thank you.

year. In the meeting they discussed with us the balance between R&A activities and other activities of the program.

One of the comments they made is that there needs to be careful attention paid to the interplay between the flight missions and the research base. We think the report was a very excellent report. We have accepted its recommendations and the first step toward implementing those recommendations does in fact appear in this budget where we have specifically augmented the R&A Program, for example in Earth remote sensing research which was singled out by the report as an area requiring particular attention, in planetary exploration and in astrophysics as well.

We will also, as we start to go through the planning cycle and the formulation cycle for the 1987 budget, undoubtedly be returning to this question, and the needs of that program will be examined once again, and we will look again at the balance between those activities and other ongoing activities in order to get the right mix for the total program.

So that I think that both the current budget, in fact, does contain an explicit response to those recommendations. We have accepted and we will be continuing to look both internally and with our committees at that question as we go forward in this next budget cycle.

Senator GORTON. The next major advance in oceanic satellite data will apparently take place some time around 1989 when the Navy's Remote Ocean Sensing Satellite will be launched along with ESA's Earth Resources Satellite.

I am told that we can obtain a synergistic effect by launching Topex at that period so that it could be calibrated with N-Ross and the ERS satellite.

Is this a critical consideration in the initiation and launch of Topex, and do you think we will be on time?

Dr. EDELSON. Mr. Chairman, again I would like to turn to the expert in the area, Dr. Shelby Tilford, Director of our Earth Science and Applications Division, to address that question.

Senator GORTON. We will be happy to hear him.

Dr. TILFORD. We believe that flying the scatterometer and the altimeter at the same time really does give us a synergistic approach to understanding ocean circulation on a global basis. The N-Ross scatterometer provides one aspect of understanding ocean circulation. However, to understand the full system, you have to also understand that piece which has to do with the height of the ocean, the variability, and that is what Topex addresses.

Therefore, we believe from a scientific point of view, it is very important to have those flying at the same time. This is also true for the interactions as part of the world ocean climate circulation, Mr. Chairman, which will be implemented in that same timeframe.

Senator GORTON. Are you going to make it on time?

Dr. TILFORD. I think that will be part of the fiscal year 1987 budget deliberations. We can still fly—in terms of time, we have sufficient time—and we believe that we are putting sufficient resources in the proposed fiscal year 1986 budget so that if we are considered for a new start in fiscal year 1987 we will be able to make it on time.

Senator GORTON. Thank you.

There have been media reports that Dr. Luest, the director-general of ESA, has said that if the United States does not initiate its role in fiscal year 1987 in the International Solar Terrestrial Physics Program, ESA may leave it.

Do you believe that threat? What are we doing to initiate ISTP, and do we have a similar problem with Japan?

Dr. EDELSON. Yes, in both cases, Mr. Chairman. ISTP is a very high priority program with us, all the higher because we have made contingent commitments with international partners. I will not go into it in detail, but over the last 2 years, we have held discussions with ESA [the European space agency], and ISAS [the Japanese scientific space agency], and have gone a long way toward coordinating our programs together. Each agency had a number of interesting and valuable projects in this arena: To look at the Sun, to study the solar internal dynamics, to study the flux, both radiation and particulate flux from the Sun, the solar wind, and the transport of the solar wind particles from the solar wind into the magnetosphere.

This requires a number of spacecraft placed in various orbits and trajectories to be similarly instrumented to provide simultaneous cooperative in situ measurements.

It was the most obvious thing that the various international activities in this program had to be coordinated. The United States had a project known as Open, and ESA had two projects, known as Soho and Cluster. Japan had an Open project, Open-J project. We got together over a period of the last 2 years and have formulated this international program. We signed memoranda of agreement which committed us to plan together and, contingent upon approval in our various agencies, to conduct the program together. We each have different budget cycles, we each have different approval mechanisms, and they are tied together. ESA has announced that with its new Expanded Science Program, it intends to go ahead with both Soho and Cluster. Japan has already got approval to go ahead with the next phase of their Geotail mission, and both have looked to the United States and said in effect we are ready to go ahead; I hope that we can count on you, partner.

We hope to be an effective partner in that, and will give very high priority in our budget decisions for 1987 to bring along ISTP as a new start in that year.

Senator GORTON. Thank you.

I would like now to defer to Senator Riegle and allow him to ask some questions. Then I will have some more for you.

Senator RIEGLE. Thank you, Mr. Chairman.

As you know, Dr. Edelson, we have a number of hearings going on simultaneously on the hill today, so we are having to sort of move back and forth between hearings.

I will simply say that I think the Space Science and Applications Programs are of great importance and benefit to universities and industries across our country, very particularly in my home State of Michigan. And I am anxious to see these programs continue. Although as the chairman well knows, we have struggled through the budget process in the Budget Committee and it is very difficult to find the money for all the worthwhile things that we would like to be able to do.

There are clearly limits on our capacity to fund even worthwhile activities at a time of enormous budget deficits we are struggling with. So all of our considerations take place in that framework that you well know.

You have been through the drill with OMB, so this is not anything that comes as news to you.

I have a number of detailed questions for the record that I am going to have you respond to, and I will only ask a few here in the areas that I want to quickly concentrate on this morning.

In fiscal year 1985, your office initiated a new program to provide additional funding for the Graduate Student Research Program. Moneys were set aside to make 40 awards to graduate students to pursue studies in research.

First, let me compliment you for this initiative. I personally think this is one of the best possible investments in America's future that NASA could make.

Could you inform the committee of the exact dollar amount of the funding that was provided in fiscal year 1985 for this effort and how much is included in the fiscal year 1986 budget request?

Dr. EDELSON. Thank you, Senator Reigle, for the compliment. It is a program we are very pleased with. In fiscal year 1985, 40 awardees are in the process of being selected. We have about $720,000 set aside for these awards in fiscal year 1985 which works out to be an average of about $18,000 per award. We expect to increase this amount up to $1.4 million for up to 80 awards in fiscal 1986, for over $2 million for up to 120 awards in fiscal year 1987 and beyond.

Senator RIEGLE. Let me ask you this. Can you give me just a quick sense of some of the kinds of research that is being done and some of the kinds of things that this money is fostering?

Dr. EDELSON. Yes, it is really all over. Dr. Rosendahl has been very eminently involved in that. I will ask him to sketch in some of the areas which have been involved.

Dr. ROSENDAHL. We are just completing the selection process. In fact, I intend to spend some chunk of Monday morning signing some 197 letters reflecting the 1976 applications we got from 67 colleges and universities, of whom about 24 are going to be award winners.

The applications we got and the work we are going to be sponsoring virtually span the gamut of the scientific activities of the Office of Space Science and Applications, sponsoring work in planetary research, in astrophysics, in space plasma physics, oceanography, atmospheric physics and chemistry, various aspects of the life sciences, and microgravity research as well. I think that if you take a look at the content of our budget submission and the range of scientific activities that are embodied in our budget submission, you will discover when you examine the kinds of things that are proposed and the kinds of things that we are going to be accepting for the graduate student research program, that the graduate student program basically reflects the breadth of the activities of the entire office.

Senator RIEGLE. Are we making any effort to try to allow more researchers to actually be directly involved in flight experiences?

Dr. Rosendahl. Yes, we are. Of course, we have very widespread activities in the ongoing program. Clearly, all our major programs involve university participants, NASA Center participants, the people from industry, other Government laboratories. There are, of course, activities underway in the suborbital program which we continue to believe is very important, particularly for the training of students. We have, for example, in the airborne observatory, people having a chance to develop new instrumentation, students being particularly involved in that apply there, to get results from data.

We are making a transition in the rocket program, particularly through areas like astronomy where long observing time—longer than a few minutes are needed to make a transition. The Spartan program is an area we expect university participants and students to be a part of. We are just completing a reexamination of the space shuttle, a set of experiments that were picked a number of years ago and have basically been on hold while the shuttle was delayed and we had budget difficulties in that. We expect to be accommodating, in fact, more than two-thirds of the investigations that were selected a number of years ago.

This suggests that the level of activity in that program is going to increase. We are also taking a look at providing some new opportunities with a smaller class of payloads as part of this total reexamination. So we are paying particular attention to this question. This is one which is also now being addressed in the study by the Space and Earth Science Advisory Committee. The question that they are asking and attempting to provide us some insight on is, What is the total spectrum of flight opportunities from these individual student class opportunities to the large facilities and observatories that is really needed to put together a viable program that makes provisions for the future, as well as just developing hardware?

We expect to be working rather closely with them. We think the subject is an important one. The long-term nature of our program requires that we plan very, very carefully, in particular in conjunction with the universities, to ensure that there is a steady flow of new talent into the program and that we look to the future as well as just to the hardware developments and plan accordingly.

Senator Riegle. I share that feeling, and I think the more we can offer that kind of relevant participation and broadening out of the connecting links, the better off we are going to be.

Along the same line of investing for the future, the committee's 1985 authorization report, as you would know, strongly supported increased funding for university instrumentation and equipment and strongly endorsed the NASA/University Relations Study Group Report.

How much funding was included in the 1985 operating plan for university instrumentation and equipment, and how much is included in the 1986 request?

Dr. Rosendahl. I might note in answering that question that I was a member of that NASA/University Relations Study Group and, of course, was a party to developing that set of recommendations. We have not explicitly included the budget line for instrumentation per se in either budget request. However, I should point out that one of the important functions of the Research and Analysis Program is to make provisions for funding upgrades of laboratory and instrumentation to bring in new pieces of equipment into the program, and to generally support work at university laboratories.

I have done a very detailed historical study of what fraction of that research and analysis budget has been devoted to instrumentation, and the number that seems to be right is about 10 or 12 percent, of that nature; 10 percent is the round number. So that I think that both in the 1985 operating plan and in the 1986 budget submission, one can expect about 10 percent of the total research and analysis budget to actually go into the upgrades of laboratory instrumentation.

I might further note also—and we are aware that places like the Defense Department and the NSF have provided explicit funding for university instrumentation—that in assessing the needs of our program, we feel that the instrumentation ought to be coupled to the ongoing research programs and meet the needs of those programs that we pick through the competition and the awards, and the grant and contract process. And so, we have decided that the best way to continue to meet the needs of university instrumentation is through normal awards in the R&A Program rather than establishing a separate line.

We have also encouraged our discipline chiefs and managers in developing their operating plan to pay particular attention to this issue. They deal very closely with the university research groups, are aware of the issues, and are attempting to meet those needs where we can.

Senator RIEGLE. When we talked to the National Science Foundation about this in our hearing the other day, they were very concerned, and were explicit in saying that we are behind in terms of keeping our equipment up to date, and that the speed of technological change is such that the outdating of equipment is happening faster and faster.

And I believe the estimate that we were given was that something on the order between $1 and $10 billion would be needed in the way of an ongoing commitment to really do this job. And I gather that other nations are focusing perhaps more intently than we are on making sure that their scientists and people who are on the sort of horizon zone of exploration efforts have the best equipment, have state-of-the-art equipment, and I am concerned that maybe we are not doing enough in that area.

So I would like to just leave that thought in your mind and urge you to follow up on that and see what more might be done along that line.

I want to move to the Materials Processing in Space Program, which I think along with your communications and remote sensing programs represents perhaps the most promising short-term commercial market. It also represents a most promising arena for the development of drugs that could cure or control severe medical disorders such as diabetes and cancer.

In light of these factors, why will the Materials Processing in Space Program receive such a modest increase in 1986? I understand it is increased from $27 million in fiscal year 1985 to about $34 million in fiscal year 1986.

Why are we moving so slowly in that area when it looks as if there is a lot of promise there?

Dr. **Edelson**. We certainly agree with you, Senator Riegle, in the importance of that area. We are emphasizing it, I think, to the maximum degree that we can, and which the state of the art and the readiness of university and industrial research community response is.

Our about 25-percent increase, which is about what the $27 to $34 million is, is a significant one. We also increased it in 1985 over 1984 by a number of about $5 million, I believe. Coupled with the $34 million which we will spend, Senator Riegle, there will also be significant amount of money that will be put into the NASA commercialization budget which is not in my office, but in that of Ike Gillam who is Assistant Administrator for Commercial Programs.

With that introduction, I would specifically like to ask Richard Halperin, who is the Director of our Microgravity Science and Applications Division, to tell you about some of the initiatives we are getting started on in 1985 and will continue into the 1986 program.

Mr. **Halpern**. Without any kind of a specific question as to initiatives, I guess what I would like to do, if it is all right with the committee, is just mention a few that I am particularly excited about. The first one that comes to mind is a project that we have started in protein crystal growth in conjunction with Prof. Charles Bugg at the University of Alabama in Birmingham. We have seen evidence of the ability to grow large crystals in space and, using these crystals, produce x-ray defraction maps of the proteins and so get a three-dimensional structure of large proteins.

Once having done that, we are able to design drugs specifically to be used to counteract the adverse effects of these proteins. The idea of producing drugs for such things as rheumatism, influenza—I do not want to touch on some of the catchy words that keep coming up like cancer cures and so forth—but frankly, Professor Bugg and his colleagues at the University of Pennsylvania, the University of Arizona, as well as a number of drug companies which are involved in this project, such as Upjohn, Schering, Burroughs-Wellcome, Smith, Kline & French, are all very very excited about the possibility of doing just that.

That is one of the things that we will be starting—we have started, excuse me.

Another thing that we have started is a project to enable us to produce pure cyrstals for use in the electronic detector field. This project which we call the advanced automated directional solidification furnace, will enable us, we think, to work both with mercury cadmium telluride, which is a very interesting detector material, as well as gallium arsenide. And, in that regard, I might point out to you that we have received, and have just officially approved, a proposal for the investigation of gallium arsenide that was submitted to us jointly by GTE and the Air Force. The program that we have instituted in that sense is a tripartite operation where GTE, a commercial organization, is putting in a third of the funding; the Air Force is putting in a third of the funding; and we will be committing to a third of the funding.

Those are just a few of the things that we will be starting, have started in 1985, and will continue into 1986.

Senator **Riegle**. Let me just ask you this. In a briefing that was given to this committee in January, it was noted that 96 percent of the materials processing research and analysis money for fiscal 1985 already was obligated. So it would seem to me that there is really an incredible interest in materials processing and obviously reflecting what is, in the view of many, a great potential for breakthroughs.

And I am wondering, in light of that, in light of the fact that you are seeing that kind of surge, particularly out of the private sector and even other government agencies, why this program should not be given a higher priority and therefore more money?

My understanding is that the European Space Agency and the Japanese are giving significant support to materials processing. I am told that the European Space Agency recently agreed to fund microgravity research at the $65 million a year level for the period of 1988 through 1992, which would seem to mean that they really see this as an area that they want to move into and with some vigor.

So I am wondering about that.

And finally, in responding to that, could you explain the difference between the centers of excellence funded under your budget and the proposed centers for commercial development? I am wondering how these centers are going to interact and how your office is going to interact with the Office of Commercial Programs. And do you expect to fund any additional centers of excellence?

Dr. **Edelson**. Let me take a crack at that, Senator Riegle. I think we agree with everything that you are saying. That is an important and exciting new field which is worthy of high priority and we should put as much into it as we possibly can.

Our approach—and let me say parenthetically, I think that the amount of money that we do have is adequate to reach the goals and to support the kind of balanced program that we have. Now, our money from the Office of Space Science and Applications is directed largely at the basic and applied research. It is aimed at getting the facts, to get an understanding of the physical-chemical processes involved in low gravity environment.

We have very little store of knowledge. The total number of experiments and the total hours at this time have been very slight. We will build that up tremendously in the space shuttle flights and later in the space station program we are funding. But rather than simply throwing money at flight experiments—tests, I should say—we are trying to put together a carefully balanced and comprehensive experimental program involving an attempt to get an understanding of the process involved. As you know, we have supported research on crystal growth, on separation through the electrophoresis, isoelectric focusing process, and others. We are engaged in a program that we feel will give us an understanding of that.

At the same time, we are entering into joint endeavor agreements and technical exchange agreements with industrial groups—the 3-M Corp., Microgravity Research Associates, and many others—whereby we work with them. They provide the funding for the experimental work. We provide funding for our own side; no exchange of funds, but we will provide the shuttle launch; in some cases, some of the facilities that are required; and we work together with them.

It is Ike Gillam's responsibility through his budget to put money directly into commercialization of these processes and Mr. Halpern will work very closely with Gillam's office to do that.

Senator **Riegle**. Just one other thing. Senator Matsunanga has asked if I could pose a question for him.

Senator **Gorton**. Go ahead.

Senator **Riegle**. I thank the Chairman.

Senator Matsunanga asks: As you are aware, last fall the President signed Senate Joint Resolution 236, calling for an effort to renew the U.S./U.S.S.R. Space Cooperation Agreement.

In light of the absence of this agreement, how does NASA interact with the U.S.S.R.?

Dr. **Edelson**. We had an umbrella agreement for cooperation in space missions with the Soviet Union which expired and was not renewed in 1982. At the time that that umbrella agreement came to an end, we had several bilateral and multilateral agreements ongoing which we have continued with the Soviet Union. We had a good and healthy two-way science agreement in the field of bioastronautics, in space medicine, and in life science. That has continued, and we have participated in the Biosat launch, December a year ago, in which we provided instrumentation on the Soviet spacecraft. They have invited us, and we have accepted, to participate in a biosat reflight launch with them. We have been involved with a multilateral agreement with the Soviets, with the French, and with the Canadians on an international search and rescue satellite program which, as you may know, has been phenomenally successful, has saved more than 356 lives at sea and ashore through boats and airplanes that have crashed, and even recently a racing automobile that was wrecked in Africa. That healthy operating agreement continues.

We also have participated with the Soviet Union, with ESA, with the Japanese, in the International Halley Program in which we are participating together in various ways. The U.S. role is manyfold. We have several spacecraft missions with use of the space shuttle, and we are deeply involved in providing the tracking. The Soviets actually have two encounter spacecraft, the Japanese have two, and the Europeans one. All of those are continuing.

Specifically answering your question, starting new areas of cooperation with the Soviet Union would be difficult, I believe, unless we had some type of umbrella agreement with them.

Senator **Riegle**. As you may know, there has recently been introduced in the Senate. Senate Joint Resolution 46 of which the chairman of the subcommittee here is the cosponsor, and which would direct the Administrator of NASA to explore the opportunities for cooperation in conjunction with the 1988 Soviet and 1990 United States Mars missions, and prepare a report examining opportunities for future international cooperation in Mars-related activities such as a manned Mars mission.

How do you react to that?

Dr. **Edelson**. We have, of course, Senator Riegle, met with the Soviets at various periods of time and we are aware of their science programs and they are aware of ours. The scientists meet at international meetings and so on.

There is not much I can say about a manned mission to Mars. As you know, that is something that would be possible perhaps in the first or second decade of the next century.

Senator **Riegle**. But to back up from that, if we are both going to be out there trying to do some exploration, might this not offer perhaps a unique opportunity to see if we could not somehow maybe combine the effort in the interest of both economy of effort, but also the development of some goodwill here?

Dr. **Edelson**. Yes, indeed, there are possibilities there. One of our future missions which we are now planning is a lunar polar orbiter. The Soviet Union is planning also a polar orbiter of the planet—I am sorry, let me start over.

A mission which we already have approved is known as the Mars Observer which is Mars polar orbiting. The Soviets are planning a similar mission and also a visit and rendezvous with the moons of Mars, specifically Phobos. And we have talked to them about the possibility of some coordination and even cooperation. However, we have not talked with then agency-to-agency.

Senator **Riegle**. What prevents that?

Dr. **Edelson**. Well, I don't know that it is preventive. This is not my field of endeavor. Perhaps you should ask our International Affairs Director.

But, I believe that that awaits the kind of umbrella agreement that we have. The discussions which have taken place and which continue to take place are scientist-to-scientist. And I would say that if we were to have cooperation with the Soviet Union, that it would be in our—several Mars missions which we are conducting and planning would be a fruitful area to discuss.

Senator **Riegle**. Well, I agree with you and I am pleased to have you make that observation.

Let me not take any more time now. I do have other questions I am going to submit for the record.

Senator **Gorton**. Senator Rockefeller.

Senator **Rockefeller**. Nothing, thank you.

Senator **Gorton**. I would like to go back to ask you some questions about Landsat and last year's Land Remote Sensing Commercialization Act of 1984; specifically, what you have done to pursue this direction on the part of Congress, and what kind of R&D efforts NASA has undertaken on its own or with other Federal agencies, or with public and private research agencies.

Dr. **Edelson**. Again, I am going to ask Dr. Tilford to address that question specifically. NASA has conducted, over a long period of time, a remote sensing program. We were responsible, as I am sure you are aware, for developing the meteorological satellites, weather satellite balloons that you see on your television each evening, and also the land observing satellites and the sea observing satellites.

So we have had series which have been known in the past as Tiros, Nimbus, Seasat, Landsat, and so on. The operating agency is, as I am sure you are aware, NOAA.

NASA has in the past developed the satellite systems and more recently developed the new high technology instruments, turned these over to NOAA when they are ready, and NOAA has flown them. With the new commercialization effort in the ATPAC passed by Congress and the procurement activity undertaken by the Department of Commerce to sign up a commercial operator for the Landsat satellites, the question has gotten confused.

At the present time, confusion in that area is quite great because until they settle the question of whether there will be a commercial operator or whether NOAA will continue to operate the spacecraft, we don't know who our customer for advanced development is, and what the requirements of that customer will be. And so with that confusing introduction, let me ask Shelby Tilford to follow up and give you the details of how we are responding.

Dr. TILFORD. Specifically with respect to the remote sensing aspects of your question, I think if you will look in the 1986 budget you will see significant increases in terms of development of the synthetic apperture radar on the one hand and the development of the shuttle imaging spectrometer, which is essentially an advanced MLA concept. It is a two-dimensional array rather than a linear array.

Senator GORTON. Why did you make that change?

Dr. TILFORD. I think, very simply, we made the change because you can buy components essentially off the shelf right now for flying a linear array. Where the advanced technology, the advanced information, and the indepth information we believe is going to come from is providing not the same kind of channels that we are now looking at with thematic mapper—that is a few fairly broad wavelength bands—but by looking in detail at a whole series with somewhat higher resolution spectra, such that if we are looking for geological purposes, we look at one set of wavelengths and look at changes where we can actually identify, as we have demonstrated with recent aircraft flights of a prototype of this instrument, we can actually identify minerals in a way that we have never been able to achieve before from space.

If you are looking at agriculture by programming a different set of channels, then you can look at crop health productivity, et cetera. We believe that the maximum amount of information for any of these remote sensing capabilities will be dealt with not by series of a few individual bands, but by grouping together the bands for systematic studies. So, we think that the next significant step is going to be the two-dimensional rather than the one-dimensional concept.

The other area that we are still pursuing is trying to develop linear array technology in the near infrared, and also in the far infrared, and we hope to pursue that. So I believe it is the advanced capabilites in terms of technology development that we are trying to pursue.

Simultaneously, as Dr. Rosendahl indicated, we have enhanced the research and analysis program within the land processes program, and we are trying at the same time to involve a greater proportion of the university community so that we can develop a science community in the land processes area, much as we have done in the atmosphere and the ocean areas.

Senator GORTON. Do you have any idea how long this technological step will take and how much it will cost?

Dr. TILFORD. We expect it will cost $60 to $75 million and I would hope to fly the first shuttle imaging spectrometer in the very early 1990's. We expect that based upon our previous experience with utilization of Landsat, it will take at least a decade to 15 years to fully develop that capability in order to make maximum utilization out of it.

One place where I believe that we have not done enough is trying to understand the products from Landsat for a number of scientific purposes and trying to understand what the signals are telling us, rather than trying to just do statistical analysis. And, so the emphasis of our program over the next few years, we will try to understand the physics so that we will know what we can do and what we cannot do in this area.

Senator GORTON. We understand that a retrieval repair mission of Landsat-4 is technically feasible and that NASA would conduct it if NOAA requested and funded the mission.

Is there any interest on NOAA's part in that or in anything else relating to Landsat?

Dr. EDELSON. We have conducted a study, Mr. Chairman, and submitted to Congress, indicating that orbit repair or recovery of a Landsat would be technically feasible. We have not gone forward with it for funding out of my office because there is limited scientific value in that.

We have had a number of discussions with NOAA, and NOAA has essentially said that they would be interested in it if it were continued in operations, but they don't know whether they will continue in operations. Perhaps we should talk with the commercial potential, commercial operator. And we have talked with them about it, and they say well, we don't know whether we are going to get that role or not.

So that it is one of the items which is up in the air.

Senator GORTON. The question awaits a firm decision on commercialization then. Let's look at it from the other point of view. When Landsat-5 ceases to operate and if we don't retrieve and repair Landsat-4, what will be the likely consequences in your view if we just get out of this business entirely, relative to the French system?

Dr. EDELSON. Well, the consequences of that would be bad, Mr. Chairman. The continuity of service is absolutely essential for the scientific and applications community that depends upon the remote sensing capability.

The French are going ahead. The French Space Agency has put a high priority on their Spot program and are planning a series of spacecraft which have very good performance, higher resolution than Landsat has, and similar, not quite as good, spectral scope and spectral resolution.

So that would be a loss to the United States of an important capability and continuity of service.

Senator GORTON. What about the other alternative for Landsat-4, recovering it and using it for a new mission, perhaps the space infrared telescope facility?

Dr. EDELSON. Yes. That question is based upon the fact that Landsat, as many other spacecraft, has been built with the MMS [multimission spacecraft]—another case where I knew the initials and could not remember what it stood for—MMS, the multimission spacecraft.

Those are a set of modular components, attitude control system, control and data handling, communications power system, which make the spacecraft somewhat less expensive because they are using proven components over and over again and repairable on orbit.

The thought has arisen that we could capture the Landsat spacecraft, return it to Earth, and even if we did not use the remote sensing instruments, the multispectral scanner, or the thematic mapper, we would use the spacecraft bus itself and the spacecraft modules for some other mission.

Whether or not it would be appropriate for SIRTF, I do not know; that would have to be determined from an engineering point of view.

It would also have to be determined whether that alone would make it an economically feasible thing to do. I would hope that if we did get the spacecraft, we could use both the spacecraft capability, both platform capabilties and the instrument capabilities.

Senator GORTON. Bring us up to date now on the space telescope. Jim Beggs told us it is 2 months behind a little while ago. Is that still the case? And he also reported that there might be a couple of surprises with respect to the cost of operating the Space Telescope Institute.

Are those good surprises or bad surprises?

Dr. EDELSON. Well, of course, Mr. Chairman, we do not know what the surprises are.

I will introduce Jim Welsh who is the director of the special division we set up to manage the Hubble Space Telescope Program. I am pleased to say that at the present time, though we have had many problems with the Space Telescope Program in terms of organization, in terms of contractor responsiveness, and in terms of hardware and software interface and technical problems, funding and schedule, that we are at the present time within the overall need schedule, within the overall budget, and are meeting or exceeding all of the science and technology specifications for that program.

Having said that, I will have to admit that we are hanging on by our fingernails. We are using the program reserves that we have, the contingency in headquarters program reserve. Various units are behind schedule a week or two and as much as 1 month and in some cases 2 months, which is I believe the figure that Mr. Beggs gave, and that we have several serious technical problems yet to overcome.

I will introduce Jim Welsh to amplify on that.

Mr. WELSH. As to the 2-month schedule delay Mr. Beggs referred to, that was principally due to some anomalies found in the ground support equipment and in the System Automatic Test Software Program which runs the entire testing system of the spacecraft.

We believe that we have uncovered every discrepancy that existed in the system. There will be a few minor ones later on, but we have essentially corrected those, and they are in final verification right now, this week.

So my estimate is that if it became necessary to recover the full 2 months, it would cost less than $1 million in premium overtime. But my estimate right now is that that will not become necessary. We have, I think, slack time built into the program to prevent that.

Dr. **Edelson**. Jim might have mentioned, Mr. Chairman, that we have just completed a major milestone. I have here, which I will leave with you, the photograph of the Hubble Telescope completely assembled.

This is the first time it has been brought together, the optical telescope assembly, with the support system module. That is to say, the telescope instrument and the spacecraft; the former built by Perkin-Elmer; the latter by the Lockheed Missile & Space Co.; and it is all together in the vertical assembly environmental test area at Lockheed in Sunnyvale now. And we are into the functional tests. So that we are now in kind of a serial set of tests. We will go into a modal vibration test, an acoustic test, and a thermal-vacuum environmental test.

And we have high hopes that all the tests will be satisfactory and we will keep it on schedule.

Senator **Gorton**. Thank you. We will include that in the record.

[The illustration follows:]

[The statement follows:]

Statement of

Dr. Burton I. Edelson
Associate Administrator for
Space Science and Applications

National Aeronautics and Space Administration

Mr. Chairman, members of the Subcommittee:

It is a pleasure for me to be here today to discuss with you the proposed FY 1986 budget for the Space Science and Applications program.

This program is a vital and exciting part of our national space effort. It involves many different scientific and engineering disciplines. It has several distinct but related goals --- to create new scientific knowledge, to develop new technologies and new capabilities, and to apply these technologies and capabilities to benefit this country and all humanity.

To meet these goals, we are involved with the entire universe. We are observing and measuring the distant stars and galaxies, we are exploring our close cosmic neighborhood, the solar system, and we are using the vantage point of space to study the global behavior of our own planet Earth. We are actively concerned with using manned capabilities in space for further experimentation and application in microgravity science, materials processing, and biomedical sciences. We are developing new and valuable remote sensing techniques for investigating the Earth. We are developing advanced technologies for better communications and data management. And we are already planning for a new era in space --- the active use of the Space Station and its associated platforms for increased scientific discovery and practical applications.

HIGHLIGHTS OF THE PAST YEAR

Before presenting the FY 1986 budget, I would like to review with you several of the most exciting highlights of our past year's activities.

PLANETS AROUND OTHER STARS?

Ground-based observations in 1984 supported by our Research and Analysis activities, provided some exciting contributions to the long debate about whether other stars have planets. A disk of solid particles was detected around the star Beta Pictoris, confirming earlier discoveries of such disks by the Infrared Astronomy Satellite (IRAS) two years ago, and studies of the disk suggest that larger, but undetectable, planets may exist close to the star. In December 1984, a body larger than Jupiter was detected circling the star van Biesbroeck 8. Much bigger than any known planet, but smaller and cooler than any known star, this object may be the first "brown dwarf" ever observed, something intermediate between giant planets like Jupiter and the smallest stars.

SOLAR MAXIMUM MISSION (SMM) REPAIR

The spectacularly successful repair of the Solar Maximum Mission (SMM) spacecraft was performed by astronauts on the Space Shuttle 41-C mission in early April 1984. Some important new discoveries in solar physics have already come from the repaired Solar Max. A large flare, observed on April 24, 1984 (only two weeks after the repair mission), displayed the most intense and longest-lasting emission of gamma-rays and hard x-rays ever observed. The new Attitude Control System for Solar Max points the spacecraft better and holds it steadier than the original one, and the change has greatly improved the images and data obtained by several instruments. The successful repair also made it possible to initiate new ground-based operating procedures, one of which has increased the time resolution of the Ultraviolet Spectrophotometer by a factor of ten. As a result, we can now match the variations seen in hard x-rays of solar flares with variations in the ultraviolet.

ACTIVE MAGNETOSPHERIC PARTICLE TRACER EXPLORER (AMPTE)

The successful launch of three spacecraft into Earth orbit by a single Delta rocket in August 1984 initiated the research phase of the international AMPTE program to study the solar wind and the near-Earth space environment. The three spacecraft are the Ion Release Module (IRM) from the Federal Republic of Germany, the United Kingdom Subsatellite (UKS), and the Charge Composition Explorer from NASA. In the fall of 1984, the IRM released two clouds of tracer ions into the solar wind on the sunward side of the Earth. These ion clouds were clearly detected by UKS as they expanded into the solar wind. In December, further tracer ion releases intentionally created an artificial comet in order to understand the basic plasma physics processes in the solar wind. In February-March 1985, additional tracer ion releases will be made in the region of the Earth's geomagnetic tail.

EARTH OBSERVATIONS FROM THE SPACE SHUTTLE

The second in a series of Earth observation payloads (OSTA-3), was flown on the Space Shuttle Challenger (STS 41-G) in October 1984. The payload contained two Earth science instruments, the Shuttle Imaging Radar-B (SIR-B) and the Measurement of Air Pollution from Space (MAPS), both of which were similar to instruments flown in November 1981. A third instrument, the

Large Format Camera (LFC), was flown for the first time. All three experiments successfully met their objectives, although the SIR-B was hampered by problems with Challenger's Ku-band communications antenna.

Although the data processing is just getting underway, the raw science data appears excellent. I'm sure we will have some exciting results to discuss soon.

EARTH RADIATION BUDGET EXPERIMENT (ERBE)

The Earth Radiation Budget Satellite (ERBS) was the first scientific spacecraft launched from the Space Shuttle. It was placed in a 57-degree inclined orbit during the STS-41G flight in October 1984. In December 1984, the NOAA-9 Satellite carried a set of companion instruments into a complementary near-polar orbit. These missions are an essential part of the Earth Radiation Budget Experiment (ERBE), which is intended to determine how much solar radiation is reflected and absorbed by the Earth's atmosphere and oceans. This information is essential if we are to understand the mechanisms behind the Earth's weather and climate.

All of the ERBS experiments are operating exactly as planned as are the companion instruments on NOAA-9. Two of the ERBS instruments are providing a new level of achievement in absolute radiometric measurements. The ground data processing system is in place, and scientifically useful products are being prepared for delivery to the scientific community early this year. Data from the third ERBS instrument, the Stratospheric Aerosol Gas Experiment (SAGE II) have already shown that the excess global aerosols produced by the 1982 El Chichon volcanic eruption in Mexico still remain at levels associated with the peak values of the 1980 Mount St. Helens eruptions, although this material is slowly being removed from the stratosphere. Scattering and absorption of sunlight by this material is expected to produce prolonged and colorful sunsets for some time to come.

These are only a few of the many important and exciting achievements of the past year, but I hope they will give you a feeling for the nature and variety of our activities. I will now turn to the FY 1986 budget request and discuss it in some detail.

BUDGET REQUEST

The total FY 1986 Research and Development request for the Office of Space Science and Applications is $1613.2 million. I believe that this funding level represents a well-structured, balanced program in the space science and applications disciplines. I would like first to touch on some of the highlights of the budget and then to provide additional details on the activities that will be supported.

The budget I am presenting will support the continuation of a scientifically challenging program at our traditional level of excellence. It includes support for continued development of the following missions, scheduled for launch as indicated:

- The Hubble Space Telescope (HST) (1986).
- The Galileo mission (1986).
- The Ulysses mission (formerly the International Solar Polar Mission) (1986).
- The Gamma Ray Observatory (GRO) (1988).
- The Venus Radar Mapper (VRM) (1988).
- The Advanced Communications Technology Satellite (ACTS) (1989).
- The Upper Atmosphere Research Satellite (UARS) (1989).
- The Mars Observer mission (formerly the Mars Geoscience/Climatology Orbiter or MGCO) (1990).

The FY 1986 budget also supports continued work in our Explorer Program and the development of instrumentation and other associated mission management activities for the Spacelab and other Space Shuttle missions. It will also support some early development work on instruments and facilities to conduct science and applications missions on the Space Station and its associated platforms. And it will continue our broad-based research and analysis activities in the space science and applications disciplines, including astronomy and astrophysics, exploration of the solar system, earth science and applications, and communications technology and information systems.

I am confident that this budget request will support an outstanding space science and applications program. The details of the FY 1986 Space Science and Applications budget request are displayed on Charts #1 and #2. I will now briefly review some of the major elements of the program.

PHYSICS AND ASTRONOMY

This year we are requesting $630.4 million for our Physics and Astronomy program. This program seeks answers to both the oldest and the newest questions about the universe and our place in it. To search for these answers, we must go above the atmosphere to observe cosmic rays and all electromagnetic radiations from infrared to gamma rays. These observations tell us about the different forms of matter and energy in the universe, about the energy sources of luminous and non-luminous matter, about the forces that sweep matter into its many forms, and about the laws of physics that govern matter and energy under extreme conditions of density, temperature, and pressure. This program carries out missions that investigate the structure, dynamics, and evolution of the universe, its galaxies, its stars, and our Sun. The funding also supports the Shuttle Spacelab mission management instrument development, and Explorer development activities associated with all of our Science and Applications program.

Hubble Space Telescope (HST)

The Hubble Space Telescope (HST) Program has now entered the process known as "assembly and verification" in which the optical telescope assembly, all of the control subsystems and the scientific instruments, are brought together and assembled to undergo system checkout and testing. Funding requested for HST in FY 1986 is $127.8 million. This observatory is the centerpiece of our Astrophysics Program. When it is launched in 1986, it will result in a vast improvement in our ability to observe and explore the rest of the universe.

HST is an international cooperative effort, involving extensive participation by the European Space Agency (ESA). The observatory was designed and developed from the outset to use the capabilities of the Space Shuttle to provide servicing and upgrading on orbit. As a result, the HST is expected to remain fully operational for 10 to 20 years, with on-orbit servicing provided first by the Space Shuttle and then by the Space Station's Orbital Maneuvering Vehicle (OMV).

Several major accomplishments have occurred in HST during the past year. The Optical Telescope Assembly was completed, tested, and delivered on time in November 1984 by the Perkin-Elmer Corporation to the system integration contractor, the Lockheed Missiles and Space Company at Sunnyvale, California. The scientific instruments successfully completed verification and acceptance tests at the Goddard Space Flight Center, and four of the five instruments have also been delivered to Lockheed. In addition, assembly of all the HST systems has begun, and initiation of final functional tests will follow.

We are now entering the final, and in some ways, the most challenging, phase of this important program. Many difficult tasks remain to be completed before launch in 1986. These include delivery of the flight model Fine Guidance Sensors, qualification testing of the remaining electronic modules of the Support System Module, functional and environmental tests of the completed observatory, and completion of the development of the many ground software systems.

Gamma Ray Observatory (GRO)

In FY 1986, we are requesting $87.3 million for continued development of the Gamma Ray Observatory (GRO) mission. When GRO is launched from the Space Shuttle in 1988, it will allow astronomers to observe the most energetic portion of the electromagnetic spectrum and to gain new knowledge about some of the most violent and explosive phenomena in the universe. We have begun to fabricate the GRO instruments and the spacecraft. In FY 1986, fabrication and assembly of the spacecraft will be continued; we will also complete assembly and calibration of the instruments.

Solar Maximum Mission (SMM)

In FY 1986, we are requesting $4.3 million for extended operations of the Solar Maximum Mission (SMM). The SMM spacecraft, successfully repaired by an astronaut team in April 1984, has become fully operational once again, and we have resumed our program of observing solar flares, the dynamics of the solar atmosphere, and the energy output of the Sun. The most significant result of the program so far has been the discovery of a global 155-day periodicity in the occurrence of solar flares. This periodicity was discovered in 1984 by analyzing data taken by SMM's Gamma Ray Spectrometer over the last four years. This long periodicity, much longer than the Sun's 27-day rotation cycle, suggests that the magnetic fields that cause flares to erupt on the Sun's surface may actually be generated deep in the Sun's interior and are not simply localized surface effects.

In FY 1986, we will continue a Guest Investigator Program that was started in FY 1985, which will involve about 20 grants to U.S. scientists to participate in data analysis. We will also support the extensive use of SMM data in two science analysis workshops on specialized topics, each workshop involving 25 to 50 scientists.

Explorer Program

We have requested $55.2 million for the Explorer Program in FY 1986. Design and development will be continued on both the Cosmic Background Explorer (COBE), scheduled for launch in 1988, and the Extreme Ultraviolet Explorer (EUVE), scheduled for launch in 1989. The program will also support continued development of an instrument to fly on the German "Roentgensatellit" (ROSAT) in 1987, as well starting fabrication of flight detectors for a cosmic ray mission called the Heavy Nuclei Collector (HNC). The Explorer Program also supports such diverse activities as the cooperative San Marco project with Italy, the development of flight experiments such as the Cosmic Ray Isotope Experiment (CRIE), and the NASA-sponsored scientific studies of ionospheric and magnetospheric processes using metal vapors released from the joint NASA/USAF Combined Release and Radiation Effects Satellite (CRRES), which is planned for launch in 1989.

One of our most successful projects, the International Ultraviolet Explorer (IUE), launched in 1978, is now entering its eighth year of continuously successful operation. The variety and breadth of its ultraviolet observations have already made a major impact on modern astrophysics, and the management methods developed for IUE will help prepare for the effective use of the Hubble Space Telescope and for following up the IRAS discoveries. We have recently received and evaluated more than 300 proposals for observing time on IUE, submitted by scientists in 31 states and several foreign countries, and we will be supporting the successful proposals in FY 1986.

Cosmic Background Explorer (COBE). The Cosmic Background Explorer (COBE) will observe the faint long-wave (infrared and microwave) radiation in the universe. This radiation now appears as a smooth background over the whole sky, representing a temperature within a few degrees of absolute zero. By detecting minute fluctuations in the intensity and temperature of this radiation, from place to place, we can learn what the structure of the universe was like just a few million years after it formed. This data will help us evaluate the "Big Bang" theory of the formation of the universe and will also help us understand the details of the process. During 1984, the cooling unit for COBE successfully passed its first major leak test. In 1985, cold-testing of the two cryogenic instruments will be conducted. In FY 1986, fabrication of the science instruments will be completed, leading to a launch in 1988.

Extreme Ultraviolet Explorer (EUVE). The Extreme Ultraviolet Explorer (EUVE) was initiated in August 1984. During FY 1986, we will continue to develop the instruments. EUVE will conduct the first survey of a portion of the electromagnetic spectrum that lies between ultraviolet light and x-rays, thus giving us our first look at the universe in a totally new region of the spectrum --- literally in a "new light." The mission is planned for launch in 1988.

In response to an innovative suggestion from industry, NASA is considering a new approach to providing a spacecraft platform for EUVE and other future Explorers. Under this approach, NASA would obtain spacecraft services through a privately-owned and privately-developed platform, which could be shared with commercial users. A Request for Proposal for such a platform was released by NASA to the industry in January 1985.

Roentgensatellit (ROSAT) Instrument. The "Roentgensatellit" (ROSAT) is a cooperative project between the Federal Republic of Germany and the United States, in which Germany will build the spacecraft and an imaging x-ray telescope. This instrument will be similar to the second High Energy Astronomy Observatory (HEAO-2 or Einstein), but it will provide higher-resolution observations of energetic, high-temperature objects in the universe. The U.S. will contribute a focal plane detector that is essentially identical to the High Resolution Imager (HRI) used on HEAO-2. The engineering model of the HRI has already been integrated into the engineering model of ROSAT, and fabrication and test of the flight instrument will be completed in FY 1986. Launch of ROSAT on the Space Shuttle is planned for 1987.

Spacelab Payloads

The Spacelab Payloads activity provides management to facilitate and enhance the use of the Space Shuttle and Spacelab systems, for science, applications, and technology research. In FY 1986, we are requesting $135.5 million for this activity. During the past 3 1/2 years, we have flown more than 20 Shuttle mid-deck investigations, three pallet payloads, one dedicated Spacelab mission, and three partial payloads. All of these payloads involved investigators from the national and international science community. We have also established and utilized the ground infrastructure necessary to assemble and fly Spacelab missions. Now that the first few science missions have successfully flown, we are making changes in hardware, documentation requirements, and other factors in order to improve the responsiveness of the system to the science community and to shorten the lead time for investigators.

Several major science and applications payloads were flown in 1984. The Solar Array Technology payload (OAST-1) flew on STS 41-D in August 1984. This mission successfully demonstrated and evaluated a large, lightweight, deployable/retractable solar array and tested advanced types of solar cells in space.

The Solar Optical Telescope (SOT) program is proceeding towards completion of the final definition phase in May 1985. Major program activities at this time include completing the finalization of interfaces between the instruments and the facility and planning for the development stage. Development phases for both the science instruments and the SOT observatory are scheduled to begin in June 1985 and will continue through the remainder of FY 1986. SOT-1 is scheduled to be launched in 1991.

Major payloads scheduled to fly in 1985 and early 1986 include:

Spacelab-3, which will employ the Spacelab module as a manned laboratory for performing experiments in materials processing, life sciences, atmospheric sciences, and technology.

Spacelab-2, which will carry out investigations in solar physics, high energy astrophysics, infrared astronomy, plasma physics, life sciences, and space technology. This mission will be the verification flight for the "Pallet/Igloo" Spacelab configuration and the Instrument Pointing System developed by ESA.

Two Materials Science Laboratory (MSL-2 and -3) missions, which will utilize the upgraded equipment support structure to carry several diverse experiments: containerless processing using electromagnetic and acoustic levitation, electronic materials processing, microgravity mixing, and solidification of unique alloys that do not mix together in Earth's gravity.

Astro-1, which consists of three ultraviolet telescopes and represents the first major step in Shuttle-based ultraviolet astronomy. These instruments will obtain images and spectra of Comet Halley over the entire ultraviolet region. These results will be combined with data obtained from European, Soviet, and Japanese spacecraft encounters and with ground-based observations made by the International Halley Watch. The telescopes will also be used to study other ultraviolet astronomical objects.

Spacelab Life Sciences (Spacelab 4), which will be the first dedicated Life Sciences mission.

PLANETARY EXPLORATION

We anticipate continued and exciting progress in solar system exploration during the coming year, beginning with the International Cometary Explorer's (ICE) flyby of Comet Giacobini-Zinner in September 1985 and continuing with the close flyby of Uranus and its moons by the Voyager 2 spacecraft in January 1986 and the historic appearance and intensive study of Comet Halley in March-April, 1986.

The FY 1986 budget request for Planetary Exploration is $359.0 million. This request includes funds for continued development of four flight programs: Galileo, Ulysses, Venus Radar Mapper (VRM), and the Mars Observer. It also includes funds for the continued operation of existing spacecraft and for supporting activities.

Two missions are scheduled for 1986 launches on the Shuttle/Centaur --- Ulysses (formerly the International Solar Polar Mission) and Galileo. The Galileo mission is planned to encounter Jupiter in late 1988, but we have recently decided to include an option that could return important science results almost immediately by making close-up observations of the 200-km-diameter asteroid 29 Amphitrite as the spacecraft speeds through the asteroid belt in late 1986. A final decision regarding the actual asteroid flyby will be made shortly after launch. All in all, we look forward to a surge of exciting new data in the next two years.

The Venus Radar Mapper (VRM) mission, initiated in FY 1984, and the Mars Observer (formerly the Mars Geoscience/Climatology Orbiter) initiated in FY 1985, have both moved off well in their development efforts toward 1988 and 1990 launches, respectively. These two missions reflect active new thrusts in planetary exploration, following closely the strategy recommended by the Solar System Exploration Committee.

Galileo.

The Galileo mission to Jupiter will conduct a comprehensive exploration of this giant planet, its atmosphere, magnetosphere, and satellites, using both remote sensing measurements from an Orbiter and in situ measurements by an atmospheric probe. The FY 1986 request for Galileo development is $39.7 million.

Significant progress was made over the past year towards the planned 1986 launch on a Shuttle/Centaur. The Galileo Probe completed its acceptance test cycle, was delivered, and was successfully mated and tested with the Orbiter. Orbiter integration, including the retropropulsion module provided by the Federal Republic of Germany, was completed. The combined spacecraft successfully completed its structural/dynamic tests and has satisfactorily completed a significant portion of the hardware/software system tests required before launch. Development of modifications necessary to prevent cosmic-ray-induced "single event upsets" in some of the sensitive electronic devices in the attitude control computer has been completed. The changes are now being implemented at the spacecraft and system levels.

FY 1986 funding will support final pre-launch calibration of the instruments and final integration tests of the flight software. Delivery of the integrated Orbiter and Probe to the Kennedy Space Center is scheduled for January 1986. The FY 1986 funding is also required for on-orbit checkout of the Galileo system after launch.

Ulysses.

In FY 1986, we are requesting $5.6 million for the Ulysses mission, a joint program between NASA and the European Space Agency (ESA). ESA will provide the spacecraft and part of the scientific payload. NASA will provide some of the experiments, the launch operations, and tracking support. Ulysses will obtain our first view of the Sun and the solar system from above, looking down on the Sun. By making comprehensive measurements over a wide range of solar latitudes, the mission will also study in detail the solar magnetic field and the streams of ejected solar wind and solar flare particles. The data obtained will provide fundamental knowledge about the Sun and will give us a better understanding of the effects of solar activity on the Earth's weather and climate.

In FY 1984 the spacecraft was placed in storage until the start of launch preparations. Also during FY 1984, a retrofit of the U.S-provided instruments was initiated; this process will be completed in early 1985. Shipment of the spacecraft to KSC is planned for late 1985. FY 1986 funding will support U.S. investigators to undertake mission planning, testing of instruments with the ESA spacecraft, ground system development activities, and initial on-orbit checkout after launch.

Venus Radar Mapper (VRM).

The VRM mission is designed to map the entire surface of Venus with radar from an orbiting spacecraft and to obtain a ground resolution of less than one kilometer. The program, started in FY 1984, has made good progress in preparing for launch in April 1988 on a Shuttle/Centaur combination. In FY 1986, $112.0 million is requested to continue VRM development.

The validity of the VRM science goals has been confirmed by the radar data returned from Venus by the recent successful U.S.S.R. Venera 15 and 16 missions. The Venera images show a geologically young and active landscape, but they also reveal unexplained features that require better ground resolution to be explained. VRM radar images will have a resolution about 10 times better than those obtained by the Venera missions, and VRM will map virtually the entire planet; Venera coverage is limited to about the northern one-third of the globe.

In FY 1984, contracts were signed with the Martin Marietta Corporation in Denver, Colorado, for the spacecraft system and with the Hughes Aircraft Company in El Segundo, California, for the radar instrument. Thirty-three scientists were confirmed as investigators for the mission, and the mission design was refined with their help. Optimization of the radar design achieved a factor of 1.6 improvement in ground resolution over that originally planned. This improvement will produce better images and will make possible the detection of smaller details on the planet's surface. The project successfully completed its preliminary design review in 1984.

FY 1986 will see a transition from design effort to fabrication, assembly, and testing. The project will complete all design efforts for the spacecraft, radar instrument, and mission operations. Critical design reviews will be held in 1985 before fabrication of flight hardware begins. Fabrication and testing of the radar development model will continue during the year, fabrication of the single flight model radar will begin, and fabrication and testing of the spacecraft subsystems will start.

Mars Observer.

The Mars Observer mission, approved as a new start in FY 1985, is the first of a series of missions recommended by the Solar System Exploration Committee as "planetary observers" to explore the inner planets. The Mars Observer will be our first return to Mars since the Viking missions in 1976. Mars Observer will utilize a modified Earth-orbital spacecraft design and will carry instruments that generally have previous spaceflight heritage. The FY 1986 request for continued Mars Observer development is $43.8 million.

Mars Observer is planned for launch in the latter part of 1990, with arrival at Mars approximately one year later; it will carry out continuous multi-instrument mapping of the planet from a close, nearly circular, nearly polar orbit for a full martian year (687 Earth days). Mars Observer will study the complex inter-related problems of martian geology, geophysics, atmosphere, and climate on a global basis, building on the knowledge --- and the questions --- developed by the Viking mission.

A Request for Proposals to industry for the Mars Observer spacecraft, and an Announcement of Opportunity to the scientific community to propose experiments will be issued in the spring of 1985. In FY 1986, we plan to select and confirm the experiments for the science payload, to select the spacecraft bus, and to award the contract for its development.

Mission Operations and Data Analysis.

This program currently supports five operating spacecraft: Voyagers 1 and 2, Pioneers 10 and 11, and the Pioneer Venus Orbiter. Minor support is also being provided for the International Cometary Explorer (ICE) encounter with Comet Giacobini-Zinner in September, 1985.

Voyagers 1 and 2 are now traveling through the outer solar system on trajectories that will eventually take them into interstellar space. Voyager 1, already beyond the orbit of Uranus, continues to provide data on the interplanetary medium. Voyager 2 will make a close encounter with Uranus in January 1986, the first time this distant planet has ever been visited by a spacecraft. ICE (formerly designated ISEE-3) is on a trajectory to fly through the tail of Comet Giacobini-Zinner in September 1985, the first encounter of any comet by a spacecraft.

Pioneers 10 and 11 continue to explore the outermost reaches of our solar system. Pioneer 10 will soon enter the unexplored region beyond the orbit of Pluto. The Pioneer Venus Orbiter (PVO) spacecraft is still studying Venus from its highly elliptical orbit, and it is obtaining data from new regions of the planet's atmosphere and ionosphere. In January-February 1986, the spacecraft will be reoriented to allow it to make unique ultraviolet observations of Comet Halley, the only opportunity to observe the comet when it is hidden from Earth during its closest approach to the Sun.

In FY 1986, we are requesting $95.0 million to support mission operations and data analysis. These funds have been increased over FY 1985 levels in order to support major activities that take place in FY 1986 --- the Voyager 2 encounter with Uranus, and the initial operations of the Galileo and Ulysses missions, which are scheduled for launch in early 1986. These funds will also support continued Voyager and Pioneer operations, including the planned extension of the Voyager 2 mission to a 1989 encounter with the planet Neptune.

EARTH SCIENCE AND APPLICATIONS

In FY 1986, we are requesting $392.4 million to support Earth Science and Applications investigations. Included within Earth

Science and Applications are programs identified under the Solid Earth Observations and Environmental Observations budget lines. Solid Earth Observations efforts are mainly concerned with investigations of the land/solid areas of the Earth and the Environmental Observations efforts emphasize the scientific studies of the oceans, atmosphere, and magnetosphere. The goal of this program is to understand the many interacting mechanisms involving the Earth and its near-space environment --- the energy received from the Sun, interactions between atmosphere and oceans, the movement of large crustal blocks, and the dynamics of the Earth's magnetic field. We study these processes with a combination of spacecraft missions and ground-based supporting research, in order to understand them well enough to develop predictive models for such phenomena as crustal movements, weather, and climate.

Upper Atmosphere Research Satellite (UARS).

The Upper Atmosphere Research Satellite (UARS) is the next important step in a comprehensive program of research, technology development, and monitoring to understand the effects of human activities on the atmosphere. UARS, approved as a new start in FY 1985 and scheduled for launch in 1989, is the critical element in NASA's overall stratospheric research and measuring program. The mission will provide the first complete data set on stratospheric composition and dynamics by making integrated global measurements of ozone concentration, other chemical species, energy transfer, temperature, and winds in the stratosphere and mesosphere.

We are requesting $134.0 million in FY 1986 for continued development of UARS. Last year, design of the ten UARS scientific instruments progressed as planned, and all preliminary design reviews were satisfactorily completed. Eight of these instruments are domestic, and two are being provided by foreign countries, one from the United Kingdom and one as a joint endeavor between Canada and France. In late 1984, General Electric's Space Systems Division in Valley Forge, Pennsylvania, was competitively selected to carry out the observatory development and system integration phases of the program.

During FY 1986, instrument design for UARS will approach 90 percent completion, and we expect to complete five of the instrument critical design reviews. The Observatory preliminary design review is scheduled for May 1986. The 20 domestic and foreign Principal Investigator teams will continue to be involved in our design coordination activities and will also continue to develop their individual science data interpretation techniques.

Scatterometer.

Our FY 1986 budget request includes $31.7 million to continue development of a Scatterometer, a radar instrument to be flown on the Navy Remote Ocean Sensing Satellite (N-ROSS) in 1989 to make accurate global measurements of ocean surface winds. In addition to satisfying Navy operational requirements, these data will make possible the first global study of the influence of winds on ocean circulation and will provide the basis for improved marine forecasting. Design and development activities of the Scatterometer were initiated in 1984 and are continuing in FY 1985. These activities will continue in FY 1986, leading to a critical design review and to the completion of the engineering model of the Scatterometer instrument. An Announcement of Opportunity for scientific investigations has just been issued, and we expect to select the first group of investigators in November 1985.

Earth Radiation Budget Experiment (ERBE).

We are requesting $2.0 million to continue the Earth Radiation Budget Experiment (ERBE) in order to measure how solar energy is absorbed, reflected, and re-emitted by the Earth's atmospheres and oceans. This information is essential if we are to understand the mechanisms behind our weather and climate. The program achieved a major goal in 1984, with the launch of the Earth Radiation Budget Satellite (ERBS) by the STS 41-G mission. The instruments on ERBS are operating exactly as planned. During FY 1986, the ERBE science team will continue to collect, analyze, and archive the ERBE data; in addition, the last set of ERBE instruments will be launched on NOAA-G.

Other Projects.

The budget request contains $4.5 million for continued development of payloads for the Tethered Satellite System (TSS), a joint program with the Italian government. The National Research Council of Italy will provide the satellite for TSS, and NASA will provide the deployment mechanism and overall systems integration. TSS will open new areas of scientific research not currently possible because tethered experiments can be extended upward or downward from the Space Shuttle's orbital altitude. A payload, lowered 100 kilometers below the Shuttle to 180 kilometers altitude, can globally study a region of the Earth's atmosphere which is presently accessible only by occasional rocket flights; the same payload can also make high resolution crustal geomagnetic measurements. Furthermore, a conducting tether can be used to generate large amplitude hydromagnetic and electrodynamic waves to study space plasma phenomena. The FY 1986 budget for TSS will support continued development of instrumentation to be flown on the first TSS mission to gather scientific data and to evaluate the capabilities of TSS.

We are also working on several projects to expand our ability to observe the Earth's surface from orbit and to increase the yield of scientific data obtained from such remote observations. We are now in the process of planning to upgrade the Shuttle Imaging Radar (SIR) from the SIR-B instrument (which flew in October 1984) to SIR-C. This new instrument will be able to operate at several different radar frequencies and in several different polarization modes. One of the anticipated gains from these new capabilities will be a better characterization of ground vegetation from oribt. The first flight of SIR-C is tentatively planned for late 1988.

A complementary instrument, the Shuttle Imaging Spectrometer Experiment (SISEX) will be a major improvement over earlier experiments for observing the Earth's surface at different wavelengths. SISEX will make rapid multispectral characterization of multiple separate ground points and the experiment will be, in fact, the first flight of an imaging spectrometer for orbital remote sensing of the Earth. The increased data yield will produce important benefits in a wide range of scientific disciplines. The flight of SISEX is tentatively planned for 1989 or 1990.

LIFE SCIENCES

In FY 1986 we request $72.0 Million to continue the Life Sciences Program. This program has two major goals: to provide the scientific, medical, and biotechnical base needed to insure safe and productive manned spaceflight activities and to conduct fundamental research to advance our understanding of space-related biological processes.

A major effort in our program is to understand and counteract the adverse physiological changes that occur in humans during the weightless environment of space flight. Intensive investigations are now underway, both in space and in ground-based laboratories, to develop and test countermeasures that will facilitate the transition of human beings into space and back to Earth again. These studies, which have immediate application to the Space Shuttle Program, are also part of our preparation for long-term missions in the Space Station era.

Basic research in Life Sciences is aimed at several problems of both scientific and practical interest: the interactions between life and gravity, practical food production in space to minimize resupply problems, and understanding the origin, evolution, and distribution of life and life-related molecules throughout the universe. Life Sciences is also a strong participant in the interdisciplinary NASA program directed at understanding biological influences on the chemical, geological, and atmospheric interactions required to sustain life on Earth.

In FY 1986, Life Sciences will use the Spacelab module to conduct the first dedicated life sciences mission (Spacelab 4), scheduled for launch in early 1986. Spacelab 4 will contain the most comprehensive set of biomedical investigations ever assembled in space. These investigations are designed to gather the inflight data required to help solve existing Space Shuttle operational problems; they will also build the investigative program needed to resolve known medical problems of long-term space flight and to understand the effect of gravity on living organisms. The unique, space-qualified biomedical equipment developed for this mission will also be used for life sciences investigations on other future Spacelab missions, such as the International Microgravity Laboratory and the cooperative Japanese (J-8) flights.

The FY 1986 Shuttle missions will also include basic gravitational biology experiments focused on understanding animal and plant gravity perception and the effects of gravity on animal and plant structure and development. In addition, we will initiate research on a demonstration model for a regenerating life support system and will prepare for the development of a flight unit for the early 1990s.

Ground-based biomedical efforts during FY 1986 will emphasize acute operational medicine problems aboard the Shuttle and will intensify preparation efforts for Space Station. The primary focus of Shuttle biomedical research will be directed toward resolving space adaptation syndrome problems, especially space motion sickness. Other efforts focus on reducing the risk of "the bends" during extravehicular activities, developing countermeasures to bone mass loss problems, and improving non-invasive diagnostic and imaging devices. In addition, emergency and health maintenance requirements for the Space Station will be developed and refined.

MICROGRAVITY SCIENCE AND APPLICATIONS

In FY 1986, we are requesting $34.0 million for Microgravity Science and Applications activities. The program scope has been broadened to concentrate on two primary goals: first, to use the microgravity environment of space in order to understand better the basic phenomena of physics, chemistry, materials science, and materials processing; second, to use this basic research to develop practical applications. In FY 1986 we will continue both a flight program and ground-based research in the areas of metals and alloys, electronic materials, glass and ceramics, biotechnology, combustion science, fluid dynamics, and transport phenomena. Ground-based experimental capabilities (drop tubes, drop towers, and aircraft) will support both scientific and commercial participants in the program.

An enhanced flight program utilizing the full capabilities of the Space Shuttle will also be pursued. The current Space Shuttle system can provide an environment of approximately 10^{-4} g's for periods of up to 10 days, in both the Middeck Locker Facility, where small experiments can be accommodated, and in the Shuttle Orbiter Bay, where larger experimental facilities are available. A more advanced carrier known as the Materials Science Laboratory is currently being built and is expected to be flown in 1985. A third capability is the use of the Spacelab, with experiments located either within the module (where they will be operated by the flight crew) or on outside pallets (where they will be operated in an automated mode). We are also planning a series of Spacelab flights called the International Microgravity Laboratory, to utilize instrumentation that is available not only in the United States, but in Europe and Japan as well.

We are working on three commercial Joint Endeavor Agreements (JEAs) in conjunction with the Office of Commercial Programs: one with McDonnell Douglas to develop the continuous-flow electrophoresis process; the second with Microgravity Research Associates for the production of gallium arsenide crystals using electroepitaxial growth; and the third with the 3M Corporation in the area of diffusive crystal growth.

Two centers to support ground-based research on space-based manufacturing of pharmaceuticals and separation of organic materials were selected in 1984, one center to be established at the University of Arizona, and the other, in which 12 universities will participate, to be established in the University City Science Center in Philadelphia.

COMMUNICATIONS

In FY 1986 we are requesting $106.2 million for Communications to continue the development of components, devices, and systems technology required by NASA, other government agencies, and United States industry for advanced communications satellite systems. Specific programs are the Search and Rescue Program and the Advanced Communications Technology Satellite. Other activities include technical consultation, experiment coordination and operations, and a strong research and analysis effort on new technologies.

Advanced Communications Technology Satellite (ACTS).

In FY 1986, we are requesting $90.0 million to continue development activities on the Advanced Communications Technology Satellite (ACTS) program. This program will develop the high risk technologies required to ensure continued U.S. pre-eminence in the field of satellite communications. Launch of the satellite by the Space Shuttle is scheduled for late 1989. A contract for design and development of the flight and ground systems needed for technology validation for the ACTS Program was signed with RCA in August 1984.

In FY 1986, we will continue design and development activities on the communications electronics package, the baseband processor, the multibeam antenna and the spacecraft bus. We will also initiate development of the ground station and associated software.

Satellite-aided Search and Rescue (SARSAT).

We are requesting $1.3 million to provide systems engineering support for the Satellite-aided Search and Rescue (SARSAT)

Program. The International COSPAS/SARSAT project successfully completed its demonstration and evaluation phase during 1984. The system is now in regular use to assist actual search and rescue operations, and more than 350 lives have already been saved. A new Memorandum of Understanding was signed in 1984 by the U.S., Canada, France, and the U.S.S.R. to begin the operational phase of the program, in which four satellites will be operated on a regular basis. Ten ground stations are now operational. FY 1986 activities will include improvement of ground system data handling, development of new types of distress transmitters, and experiments to explore the possible use of geosynchronous and polar-orbiting satellites as instrument carriers.

Technical Consultation and Support Studies.

Unique analytical tools and techniques are now being used to solve problems of satellite/terrestrial system interference and to provide the technical basis for regulatory and policy studies needed to enable continuing orderly growth of existing and new satellite services. In FY 1986, we will perform specific studies to support other U.S. Government agencies in their preparations for the 1985-1988 World Administrative Radio Conference (WARC) on geostationary orbit planning, and the 1987 WARC on mobile communications.

Applications Technology Satellite (ATS).

Two NASA Experimental Spacecraft, Applications Technology Satellites (ATS-1 and -3), despite their combined age of 35 years, continue to provide humanitarian services. ATS-1, which reaches more than 23 locations throughout the Pacific, will continue to provide communications support for health and community services, as well as for scientific experiments. ATS-3 provides similar services in the Western Hemisphere, but on a smaller scale, and it will continue to be an important link for emergency communications in the U.S.

INFORMATION SYSTEMS

For FY 1986, we are requesting $19.2 Million to continue our multi-disciplinary Information Systems program. This program supports all of Space Science and Applications flight projects and science programs by managing major computational resources and by developing the advanced technologies needed for efficient management of the massive amounts of data acquired from missions.

Large scale computer data processing systems used for computations and modeling by researchers include the NASA High Speed Vector Computing Facility (NHSVCF), the Science and Applications Computer Center (SACC), and the Massively Parallel Processor. In addition, the program is responsible for the National Space Science Data Center (NSSDC), which archives all NASA's satellite and rocket data. These systems and facilities are all located at the Goddard Space Flight Center (GSFC).

In FY 1985, we consolidated the SACC and the NHSVCF into a single GSFC facility to permit more efficient and cost-effective sharing between these major computer systems and we will be upgrading the NSSDC facility to be more responsive to the science community's needs for improved data storage, accessibility, and dissemination.

In FY 1986, we will continue to develop improved systems capabilities for space data management, processing, and distribution; we will also provide technical consultation in key programs, such as the Space Station. Emphasis will be placed on our Pilot Data Systems program, which consists of discipline-oriented testbeds used to evaluate and demonstrate new, efficient, and cost-effective computer technologies and to provide a foundation for operational systems. This program has already proven very successful in demonstrating new capabilities for space data analysis and multi-disciplinary correlative research. For example, the Ocean Pilot will become a key data analysis element in the N-ROSS and TOPEX missions now under study.

SUPPORTING PROGRAMS

Our supporting programs in Suborbital Research and in ground-based Research and Analysis provide the essential foundation for all our flight mission activities. Suborbital flights of balloons, sounding rockets, and aircraft continue to provide important observations and research results that complement more complex space missions. The Spartan carriers, a more recent development, can be deployed from the Space Shuttle for longer periods of time, up to 40 hours. Such flights also make it possible to test new instruments and observational methods before undertaking the larger development effort needed to design, build, and fly a major Earth-orbital experiment.

The ground-based Research and Analysis program provides an even wider range of essential support functions: theoretical studies, laboratory research, instrument definition and development, complementary ground-based observations to support flight missions, and extended data analysis from completed missions. The latter task is especially critical, for the analysis of data during the mission itself cannot extract all the available information, and many major discoveries are made from continued analysis of data years after the mission has been completed. These supporting programs also provide a significant fraction of the basic research support to the university, government, and industrial scientific researchers who make up the heart of the Space Science and Applications program.

Suborbital Research.

During the last 18 months, we have experienced a number of problems with our heavy-lift balloons which we are beginning to overcome. Despite these problems, we were able to launch 44 scientific balloons in FY 1984 to support upper atmospheric science, astrophysical research, and solar physics. In FY 1985, we plan to launch nearly 55 balloons, most of them from the Scientific Balloon Facility at Palestine Texas. In FY 1986 we also plan to launch about 55 scientific balloons. We launched 40 scientific sounding rockets in FY 1984, and we plan to launch approximately the same number in FY 1985 and in FY 1986.

The first flight of the new Spartan experiment carrier is scheduled for 1985. This mission will be the first of a series that will use the Space Shuttle to extend the capabilities of our normal sounding rocket payloads by providing up to 40 hours of observing time in Earth orbit. Spartan 1 will carry an x-ray telescope to observe hard x-rays emitted by clusters of galaxies and by a supernova remnant. Spartan 2 will observe Comet Halley with an ultraviolet telescope in early 1986. Other Spartan missions are now under development.

The Airborne Science and Applications program maintains a small number of aircraft as platforms to collect scientific data and to test concepts and prototypes for instruments that will later fly in space. These aircraft, based at the Ames Research Center, include an instrumented Lockheed C-130, three high-altitude Lockheed U-2 type aircraft, a Convair 990 "flying laboratory" and a Lockheed C-141 (the Kuiper Airborne Observatory or KAO). Last year, these aircraft flew approximately 2300 hours to support field experiments and airborne observations for Earth sciences, planetary sciences, life sciences, and astronomy. We expect to provide a similar number of flight hours in FY 1986. In FY 1986, the KAO will turn its 91-centimeter infrared telescope towards many of the new infrared objects discovered by IRAS.

Research and Analysis.

Physics and Astronomy. A major new addition to our research and analysis program in solar physics and astrophysics in FY 1985 is the Astrophysical Theory Program, which will complement the Solar-Terrestrial Theory Program already under way. We are now reviewing the first 48 proposals for FY 1986 funding; they include such fields as cosmology, high energy physics, star formation, stellar physics, and plasma dynamics.

Planetary Exploration. Ground-based observations produced several exciting planetary discoveries in 1984, including the first images of a disk of solid material around the star Beta Pictoris and the first ground-based photographs of the ring system of the planet Uranus. The first spectral data were obtained from the still-distant Comet Halley; the comet is redder than expected, a color that might be due to unknown organic chemicals. Two lines of evidence suggested that there are active volcanoes on Venus: major variations of sulfur dioxide in the atmosphere since 1978, and the detection, using Earth-based radar, of landforms resembling rift valleys and young volcanoes. Closer to home, two more meteorites blasted from the Moon were found by Japanese scientists in the Antarctic.

FY 1986 will see major supporting science efforts to complement the Voyager 2 encounter of Uranus and the flybys of Comet Halley by several foreign spacecraft. The Halley flybys will also be supported by the ultraviolet telescopes on the Shuttle-based Astro mission and by the intense ground-based observational efforts of the worldwide International Halley Watch program.

Earth Science and Applications. In FY 1986, we will continue research and analysis in geodynamics, land processes, ocean processes, atmospheric dynamics and radiation, upper atmosphere phenomena and space plasma physics. We will continue the interdisciplinary research, initiated last year, to study the coupling of processes affecting the land, oceans, and atmosphere.

The Land Processes Program uses remote sensing technology to study physical interactions at or near the Earth's surface. One goal is to determine the various kinds of ecological, geological, and hydrological information that can be derived from remotely sensed data. The other goal is to use this information to better understand those processes, the interrelationships among them, and their effects on the Earth and its surface environment.

During the remainder of FY 1985, this program will continue to analyze data from the Landsat-5 Thematic Mapper, the SIR-B radar, and the airborne sensor program. The program will also support studies of new techniques of data analysis, including pattern recognition and artificial intelligence, in order to develop a more integrated understanding of processes at work on the Earth's surface. In FY 1986, the program, in conjunction with the interdisciplinary research program, will initiate studies aimed at understanding surface climatology and the natural production of methane on land.

Communications. Our efforts in communications research in FY 1986 will continue to develop technologies needed to help the U.S. maintain its competitive edge in space applications communications, to form the basis for new and innovative public services, and to enable new business opportunities for U.S. industry at home and abroad. In FY 1986, we will continue proof-of-concept hardware evaluation and market studies. Specific analyses will focus on future high risk technology needs, development of advanced modems/codecs for on-board switching and processing, spectrum-efficient microwave components, and laser and radio-frequency technology for inter-satellite link communications.

In a special project, we are requesting funds in FY 1986 to continue studies of mobile satellite communications technologies, in order to establish a system for communications links with mobile vehicles. The program will help U.S. industry develop critical technologies to conserve power, frequencies, and orbital slots. These technologies are essential to ensure initiation and growth of the mobile service. The program is expected to evolve into a Joint Endeavor Agreement (JEA) between NASA and U.S. industry.

NASA's interest in mobile satellite communications is shared by Canada; the Canadian Department of Communications (DOC) has an ongoing mobile satellite program in parallel with the NASA effort. In November 1983, NASA and DOC signed a cooperative agreement which provides a framework for NASA and DOC to participate in program definition activities and to work with the respective industries and regulatory agencies in each country to help initiate mobile satellite service. Cooperation between the U.S. and Canada in this area is desirable in order to coordinate selection of frequencies and orbital satellite locations as well as to identify potential cost reductions.

POTENTIAL FUTURE MISSIONS

The Space Science and Applications program continues to support advanced studies of possible future endeavors in order to select and plan missions that are both scientifically important and cost-effective. I would like to mention briefly some of the more exciting possibilities for the future.

ASTRONOMY AND ASTROPHYSICS

The Advanced X-ray Astrophysics Facility (AXAF) is the highest priority for a new orbital observatory in the National Academy of Sciences report, Astronomy and Astrophysics for the 1980s. It will provide new and unique views of high-energy, high-temperature objects in the universe, including clouds of million-degree gas around stars and high-velocity particle jets expelled from galaxies and quasars. We have selected four instruments to be part of AXAF, and detailed definition of these instruments will be started in FY 1986.

The Space Infrared Telescope Facility (SIRTF) will provide the essential tool for detailed studies of the exciting infrared universe recently revealed by IRAS. Last year I mentioned that we were studying the possibility of making SIRTF a long-term observatory. Now I am pleased to tell you that we have chosen this option; SIRTF will be a long-duration orbital facility maintained in orbit by the Space Shuttle, and later by the Space Station. In FY 1985, we selected three instruments for SIRTF, and detailed definition of these instruments will continue in FY 1986.

Advanced research and technology development will continue on aspects of the future Gravity Probe-B (GP-B) instrumentation. The GP-B mission would perform an entirely new test of Einstein's general theory of relativity by using very precise gyroscopes to measure a relativistic twist in the local gravitational field due to the earth's rotation. We will continue to define a test in space for the technology and equipment developed at Stanford University and at the Marshall Space Flight Center. Critical experiment components have been developed and demonstrated in the laboratory, and the long-term gyroscope testing and system-level studies are now under way.

PLANETARY EXPLORATION

Last year the Solar System Exploration Committee (SSEC) completed its three-year study of future planetary exploration by providing recommendations for more valuable and challenging "Augmentation Missions" to complement its earlier Core Program of scientifically valuable, focused, and cost-effective missions. The report on these new missions, which include a Mars Sample Return/Rover and a Comet Nucleus Sample Return, will be available later in 1985.

Last year, our Advanced Studies effort concentrated on the next mission recommended by the SSEC, the Comet Rendezvous/Asteroid Flyby (CRAF). This mission, which is planned for the early 1990s, will use the new modular Mariner Mark II spacecraft. A joint study of the CRAF mission, to define possible cooperative efforts, has been initiated with the Federal Republic of Germany.

EARTH SCIENCE AND APPLICATIONS

The newly-formed Earth Systems Science Committee (ESSC) has already made major progress in defining research needs in the earth sciences and identifying an appropriate role for NASA. In another study effort, we are continuing to review a Global Habitability concept and its relation to the International Geosphere Biosphere Project (IGBP) recently proposed by various groups in the outside scientific community. We have asked the National Academy of Sciences to review and evaluate these two complementary concepts, and we expect a report later in 1985.

In FY 1986, we will continue to study the Ocean Topography Experiment (TOPEX) mission, which would use radar altimetry to provide critical data about the general circulation of the oceans and the nature of atmosphere-ocean interactions. TOPEX is being planned as a joint mission with CNES, the French Space Agency. Our studies will concentrate on maintaining the overlap between TOPEX and the Scatterometer mission now in development to insure a maximum return of comparative information.

To understand better the nature of the Solid Earth, we are also studying a Geopotential Research Mission (GRM) that will measure the Earth's global gravity and magnetic fields with much higher ground resolution.

The International Solar-Terrestrial Physics Program (ISTP), now under study, focuses on Sun-Earth space relations. This program will involve several international spacecraft which will simultaneously observe the Sun and measure the complex behavior of magnetic fields and particle flow that take place in space near the Earth.

SPACE STATION

Our future Space Science and Applications programs can benefit greatly from the establishment of a permanent manned Space Station in the 1990's, and we are already studying the possibilities in considerable detail. Such planned elements of the Space Station as pressurized laboratory modules, servicing accommodation and workshop facilities, and major polar orbiting platforms for coordinated Earth observations will make possible more ambitious activities in many fields of investigation. Many of our ongoing programs have already demonstrated future needs for long-term orbital observations, large power supplies, and high data rate capabilities that can only be provided by the Space Station and its associated platforms.

In addition, the ability of a manned Space Station to carry out such functions as the deployment and recovery of Earth-orbital spacecraft, repair and refurbishment operations, and the staging and launch of deep-space missions will make possible an entirely new range of activities, both in Earth orbit and throughout the solar system. The successful repair of the Solar Maximum Mission spacecraft, which I mentioned earlier, is only a small example of how the scope, lifetime, and scientific value of our future missions can be increased by a permanent human presence in space.

During the current year, we are studying in detail the requirements that our planned activities for the 1990s would place on the Space Station and how our missions could be supported and enhanced by manned and unmanned Space Station elements. We also established last year, through the NASA Advisory Council, a Task Force on the scientific use of Space Station to provide advice on how to optimize the space station capabilities to support science and applications activities.

Other studies and plans are being carried out at the individual discipline level. In Astrophysics, for example, we are examining closely the possibilities for large-scale on-orbit assembly of deployable antennas and astronomical facilities, as well as servicing, parts changeout, and refurbishment of existing facilities on-orbit in order to avoid the costs of returning them to Earth and re-launching them.

In Planetary Exploration, we are examining the possibility of dedicated planetary telescopes associated with the Space Station, including instruments for possible detection of extrasolar planets. The Space Station may also make possible major, scientifically challenging missions by providing spacecraft staging operations and support laboratories for unmanned sample return missions to Mars and the nucleus of a comet.

In Earth Observations, we are actively studying the requirements for an Earth Observing System (EOS) on a polar platform, and a report of the study has just been completed.

The Microgravity Science and Applications program is developing plans for the transition of Shuttle-based instruments to the Space Station and is also developing a Microgravity Research Center at the Lewis Research Center to test ground-based equipment in an environment that duplicates (as far as possible) the Space Station. As the design of the Space Station progresses, this laboratory will evolve into a ground-based test bed which will enable us to check hardware designs as well as enhance the use of Space Station itself. This laboratory will also provide a means by which individuals proposing investigations can explore the suitability and possibilities for their experiments aboard the Space Station.

The Life Sciences program is continuing biomedical research on space adaptation problems and long-term life support in space. Additional expanded efforts involve developing a new generation of non-invasive diagnostic and treatment techniques as a step toward providing medical care and health maintenance capabilities for future long-term space travelers.

In a complementary effort to our Space Station studies, we are also seeking advice from the National Academy of Sciences' Space Science Board (SSB). The SSB acts as the focus of interest for the National Academy of Engineering Research Council in space sciences, and the SSB seeks especially to stimulate research, promote coordination of scientific efforts, and provide advice and recommendations with regard to the space sciences.

The SSB is now beginning a major two-year study of long-term future directions in the space science and applications area, and this study will take into account the new capabilities that the Space Station will provide.

CONCLUSION

In summary, the budget we propose for FY 1986 will support a healthy, active, and balanced program. The program continues our essential ground-based supporting efforts, moves forward on the development of previously approved missions, and continues our active involvement in planning for the use of the Space Station.

As I noted in the beginning, the Space Science and Applications program has established a long tradition of achievement in understanding the universe, learning about the Earth as a planet, and developing new and useful applications of space science and technology. The FY 1986 budget represents a commitment to maintain the scientific and technical excellence that have had such an important impact on the nation and the world. We will continue the outstanding efforts of the past, we will move forward on the development of current missions, and we will assure the preservation of the science research base that is critical to U.S. leadership in space.

OFFICE OF SPACE SCIENCE AND APPLICATIONS FY 1986 BUDGET REQUEST

(DOLLARS IN MILLIONS)

	FY 1984 BUDGET	FY 1985 BUDGET	FY 1986 REQUEST
PHYSICS AND ASTRONOMY – TOTAL	567.6	677.2	630.4
HUBBLE SPACE TELESCOPE DEVELOPMENT	195.6	195.0	127.8
GAMMA RAY OBSERVATORY DEVELOPMENT	85.9	117.2	87.3
SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT	80.9	105.4	135.5
EXPLORER DEVELOPMENT	48.7	51.9	55.2
MISSION OPERATIONS AND DATA ANALYSIS	68.1	109.1	119.9
RESEARCH AND ANALYSIS	35.9	39.9	42.3
SUBORBITAL PROGRAMS	52.5	58.7	62.4
PLANETARY EXPLORATION – TOTAL	217.4	290.9	359.0
GALILEO DEVELOPMENT	79.5	56.1	39.7
ULYSSES (FORMERLY ISPM)	6.0	9.0	5.6
MISSION OPERATIONS AND DATA ANALYSIS	43.4	58.8	95.0
RESEARCH AND ANALYSIS	59.5	61.5	62.9
VENUS RADAR MAPPER DEVELOPMENT	29.0	92.5	112.0
MARS OBSERVER (FORMERLY MGCO)	–	13.0	43.8
LIFE SCIENCES – TOTAL	58.0	62.3	72.0
FLIGHT EXPERIMENTS	23.0	27.1	33.4
RESEARCH AND ANALYSIS	35.0	35.2	38.6
SPACE APPLICATIONS	314.0	374.1	551.8
SOLID EARTH OBSERVATIONS			
LANDSAT-4	16.8	–	–
SHUTTLE PAYLOADS	17.0	12.1	23.1
GEODYNAMICS	28.0	29.9	31.7
RESEARCH AND ANALYSIS	14.6	15.6	20.1
SUBTOTAL	76.4	57.6	74.9

CHART #1

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Platforms for Space Station

Question 1: How many polar platforms will be needed for the space station initial operating capability and how many will there likely be?

Answer 1: There is a current interest in having several polar platforms when the Space Station becomes operational. The various potential users are having discussions, both intra- and inter-agency, to see if user needs can be satisfied by shared platforms and possibly some shared instruments. Therefore, the specific number of Space Station polar platforms is still being defined at this time.

Question 2: Do you expect that ESA or Great Britain will contribute a polar platform, as well?

Answer 2: The European Space Agency (ESA) is studying a polar platform as one part of its phase B studies. Great Britain will probably have the lead role in the ESA studies. (ESA has not chosen its phase B contractors). Decisions on international participation will be made in the timeframe of the Space Station Systems Requirement Review, halfway through the definition phase when the baseline configuration for the initial operational capability is established. NASA and its international partners will have access to all Space Station facilities at IOC.

Question 3: According to your testimony, NASA has just completed a study on the requirements for an Earth Observing System (EOS) on a polar platform. What are the findings and recommendations of this report? What are the primary drivers behind the number of polar platforms that will be associated with the space station?

Answer 3: The EOS Study recognized that earth science is increasingly faced with problems that are truly global in extent, growing in rapidity of change, and interdisciplinary in nature. In order to address these types of science problems, observations of the Earth must be employed which range in scale from detailed ground and laboratory measurements to the global perspective offered by satellite remote sensing. The Study concluded that an EOS system should be based on the synergistic use of a broad array of sensors operating across the spectrum, from ultraviolet to microwaves, and should strongly emphasize a global resource information system approach in order to effectively use the EOS derived data in combination with existing earth science data bases and on-going operational data streams. Further, it was recommended that the EOS should be evolutionary in its design and capitalize on space-based servicing and instrument augmentation and replacement, in order to provide the required long-term, time series of earth science data.

The primary technical drivers behind the number of polar platforms consist of potential weight and power limitations of individual platforms as well as the attainment of a desired compatibility between the operations of the individual instruments. The major determining factor in platform size is the payload weight capacity of the Space Shuttle for launch into polar orbit. Current estimates indicated the need for at least two platforms in the initial Space Station operational capability. A two platform system could be shared with NOAA operational instruments. The eventual number of Space Station polar platforms will be significantly influenced by the degree of interest that will be received from the international community, private industry, and other U.S. Government agencies.

Question 4: The Task Force recommends that NASA should extend the Shuttle's on-orbit capabilities from nine days to three weeks to gain a better basis of experience for the conduct of human-assisted research in space. How important is an Extended Duration Orbiter to the conduct of productive and meaningful science aboard the space station?

Answer 4: Spacelab science missions can of course, benefit from longer durations in space. Experience and scientific insights gained on shuttle missions will be critical in assessing the potential of candidate Space Station payloads in many disciplines.

Question 5: Do you agree with the NASA report submitted to Congress in November that concluded that, at the present time, the requirements for an Extended Duration Orbiter of 10 to 20 days are small, and do not warrant the development of this capability? If so, under what circumstances would this development be warranted?

Answer 5: The requirements for an Extended Duration Orbiter are a very small part of the currently identified Shuttle manifest requirements. However, some areas of science could effectively utilize longer stay time in orbit, i.e., microgravity research, life sciences research, etc.

Question 6: Dr. Banks' Task Force believes that new funds should be made available to your office for the conduct of space station research programs. This suggests a deficiency in the scope and magnitude of programs in your office that should support space station research programs. Do you believe that you need more funding for the conduct of a space station research program, and if so, how much?

Answer 6: We have recently prepared and submitted to the Space Station Program Office a preliminary listing of science and applications missions. These missions, which have been reviewed and coordinated with the Banks' Task Force, include a wide range of candidate missions and payloads which appear to be compatible with our current understanding of the Space Station's potential capabilities, and which fit naturally within our currently established science and applications goals.

Future year funding requirements will depend on the refinement of the Science and Applications missions based on the approved capabilities of the Space Station over the next several months, and the dynamic nature of research objectives which may change as new insights are gained.

Question 7: This Task Force has also stated that unless NASA devotes a significant effort to the conduct of more indepth studies of the way science operations will be done on the space station, there is a real prospect of serious difficulties later in the program. What is your response to this finding of the Task Force?

Answer 7: A Science Operations Study has been initiated to define how the Space Station can most effectively and efficiently be utilized. We plan to continue this study and coordinate the periodic findings during the Space Station definition, design, and development activities.

In addition, at our request the Banks' Task Force is undertaking an independent study of potential future Space Station science operational requirements.

Question 8: Furthermore, I understand that unless NASA makes significant progress on TOPEX in FY 1986, our French partners may disassociate themselves from the program. And, with no French participation, NASA will then have to provide approximately $70 to $80 million to launch TOPEX, an expense the French were prepared to assume. How likely is it that the French will disassociate themselve from TOPEX?

Answer 8: The French Space Agency, CNES, has recently reaffirmed their commitment to continue the collaborative effort with NASA on TOPEX, thus maintaining the prospect of greater scientific return from TOPEX at a reduced cost to NASA.

Question 9: How much does the FY 1986 budget request provide for TOPEX?

Answer 9: The FY 1986 Budget Request assumes a funding level of $4-6 million for TOPEX activities.

Question 10: How much is needed to maintain the participation of the French in TOPEX and to meet the critical launch window?

Answer 10: We believe the currently planned funding level in FY 86 is adequate to maintain the participation of the French in TOPEX. The French recently reaffirmed their commitment to a collaborative effort on TOPEX.

Question 11: NASA decided last fall to phase-out its remote sensing activities research related to the Multispectral Linear Array (MLA), in favor of developing a Shuttle Imaging Spectrometer Experiment (SISEX, pronounced SI-sex). How much money had you spent on MLA when you decided to develop SISEX in place of MLA? What benefits or applications are there from the MLA work that is being discontinued? How critical is MLA or SISEX technology to the EOSAT proposal on commercialization of the Landsat System? What factors convinced you to opt for SISEX, and why did you not make this decision prior to investing in MLA?

Answer 11: NASA phased out the development of a MLA instrument; however, some MLA technology development activities are being continued. The resources that had been planned for the MLA Shuttle demonstration instrument also included a significant amount of focal plane technology development activities. The funds expended on the instrument itself totaled less than three million dollars when we decided to terminate the instrument effort. Our plan was to re-design a Thematic Mapper type instrument to incorporate solid state detector technology, provide for off-nadir viewing and then to demonstrate the instrument as an attached Shuttle payload. As we progressed in the MLA/Imaging Spectrometer Program several things occurred which caused us to modify our original approach to accomplishing the program objectives. The main item was the fact that the advanced technology for the linear array matured to a point that a laboratory environment could be used to demonstrate maturity and the area array technology and science was being realized faster than anticipated. Coupling these developments (a mature linear array technology and a realizable area array) with the commercialization of Landsat and the advent of EOS/Space Station led us to conclude that there was a greater need (and greater return) to apply our resources to the development of the Imaging Spectrometer.

As we understand the EOSAT proposal for Landsat commecialization, their plan was to incorporate the MLA technology (primarily the linear focal plane) into an advanced Thematic Mapper type instrument. In this way, they were planning to provide the next generation Landsat system. With a three module focal plane developed and characterized by NASA, the decision not to fly a shuttle demonstration of this technology should have little impact. The Thematic Mapper type instrument collects data using a "whiskbroom" approach with discrete spectral detectors. An inherent limitation to collecting images in many narrow contiguous spectral bands is the limited dwell time for signal integration in each cross-track pixel. The linear array of detectors used in a "pushbroom" mode avoids this problem, but is limited by the number of line arrays which can be practically placed in a focal plane. A more desired approach is to manufacture an area array such that for each pixel in the spatial dimension, there exists many pixels in the spectral dimension. This is the technology of the imaging spectrometer and with the development of this instrument we expect to demonstrate the direct identification of surface cover (minerals, vegetation, etc.) from space.

Question 12: I understand that the additional costs associated with the development of the Centaur upper stage have grown to approximately $100 million. Is this correct? To what extent will this problem affect the scheduled launches of Galileo and Ulysses in May 1986? Do you have any "slack time" built into these schedules, and, if so, how much? What would be the consequences of missing either launch window?

Answer 12: The best estimate of the cost overrun for the Centaur/STS G and G Prime development program is about $100 million. The Air Force share of this overrun is approximately $20 million, since the overrun will take the program above what was an agreed-to cap for DOD of $150 million.

Our most recent assessment of the Critical Path leading up to launch of both Galileo and Ulysses in May/June 1986 indicates that while the schedule remains very tight, we believe that the reasons for the recently identified additional costs associated with development will not further jeopardize our ability to meet our launch dates.

The consequences of missing the launch window for either Galileo or Ulysses would be a 13 months delay in the launch for either mission.

We do have "slack" time built into the schedule for the first Centaur production unit. We have a 2-month storage period between processing at Complex 36, and prior to entering the vehicle processing through the STS facilities. Processing for the second vehicle is anticipated to take less time due to the learning process of having done it once. In addition, the normal work shift activity planned at Complex 36 and VPF is one shift. Usable slack time during these activities could be made available through multiple shifts and weekends.

Question 13: What factors will determine if you undertake the flyby of the asteroid Amphitrite (pronounced AM-fri-TRI-tee) during the Galileo mission to Jupiter? Who will make the decision for this flyby and at what point in the mission? What risks are associated with this potential "detour"?

Answer 13: The decision to implement the Amphitrite flyby will be dependent on the satisfactory operability of the attitude control system coupled with the ground system's capability to satisfactorily monitor and command the spacecraft. The decision will be made by the Galileo Program Office after launch, based on the post launch check-out of the above systems and recommendations by the JPL Project Office.

The risk associated with a flyby distance of 10,000 km to 20,000 km, the range of selected flyby distances, is no greater than any passage through the asteroid belt. This assessment was made by a group of asteroid scientists assembled by the Galileo Project to address this question.

Question 14: When will a decision be made concerning the need for additional protective shielding on the Galileo and Ulysses missions to guard against any problem associated with the radioisotope thermoelectric generators (RTG's)?

Answer 14: The decision has been made that no additional protective shielding for the RTG's is required for the Galileo and Ulysses missions. This decision is based on the lower than expected probabilities of a Shuttle launch accident, lower explosive environments due to accidents, and better than expected resiliency of the fuel capsules, verified by tests, to explosive overpressures.

Hubble Space Telescope

Question 15: The original development estimate for the Space Telescope submitted in 1978 was $435 to $450 million. Now, however, these development costs have grown to over $1.2 billion due to technical and management problems, as well as inflation. Surely, these unexpected increases in the development of Space Telescope have adversely affected other Space Science and Applications programs.

What lessons have you learned about managing a program of this magnitude and difficulty, and how does NASA intend to prevent in the future space science programs of this magnitude from subsuming other space science programs?

Answer 15: The original cost estimate for the Hubble Space Telescope development of $435-470 million was in 1978 dollars. Our current estimate of $1,175 million is in real year dollars. Therefore, the two estimates are not comparable.

Because NASA is a research and development agency, it is inevitable that technical challenges will be encountered in the future because each project is unique, and NASA recognized from the outset that the HST design and development activities would be a technical challenge. Therefore, it is not evident whether the HST problems could have been prevented, or exactly how much, if any, of the HST development experience can be applied to other NASA projects. NASA has always tried to make sure that high management standards are maintained on all NASA projects and programs. We will continue to strive for an in-depth knowledge of our performance at all management levels and to maintain our requirement for a clear understanding by each element of the program, both government and contractors. We will continue to emphasize a technical overview capability sufficient to understand where problems are occurring and what their cause; the need for providing sufficient financial reserves in a technically challenging program to enable managers at the various levels to meet unplanned, but to be expected, problems; and lastly, to have both schedule and cost estimates that are realistic and achieveable and to have in place systems to measure performance at all organizational levels.

Question 16: The September, 1984 OSTP report, Funding Trends of NASA's Space Science Programs recommended that as funding requirements for Space Telescope development begin to decline in 1986, NASA should carefully assess its program strengths and future mission plans to improve the balance among its major space science disciplines.

a. Do you believe that there are any inherent weaknesses in NASA's mix of space science disciplines? If so, what are they?

b. If not, will your future mission plans continue to maintain an appropriate balance?

Answer 16a: We do not believe there are inherent weaknesses in the mix of space science disciplines. Fifteen years ago the space science budget was dominated by the planetary exploration program. Since that time, we started several major new programs in astronomy which have tended to dominate the budget. Recently we started two new planetary projects and have initiated major new programs in earth sciences and applications. The situation is a dynamic one and can only properly be understood by reviewing what happens over an extended period of time.

In annually examining the detailed content of the Space Science and Applications budget, we look at what activities need to be continued, potential new starts or program augmentations, emerging new areas which need to be fostered, and interplay between work being undertaken in other parts of the program. It is the job of the Office of Space Science and Applications and NASA senior management to ensure that the most pressing needs in all areas of the program are met and that balance is maintained.

Shuttle Science Working Group Report

Question 17: According to the September, 1984 report by NASA's Shuttle Science Working Group, the Shuttle should accommodate more intermediate class scientific payloads aboard such carriers as "hitchhikers," "get-away-specials", and Spartan rockets. However, it appears that this potential has not been realized. What is NASA doing to accomodate these intermediate class scientific payloads? When will you launch from the Shuttle the first Spartan rocket, and how many Spartans will you be able to deploy in a single year?

Answer 17: NASA has incorporated specific funding for several low-cost intermediate class payloads within the FY 1986 budget request. GAS cans are currently manifested on four Shuttle flights in calendar year 1985; the first flight of a payload on the hitchhiker is scheduled for December, 1985; future hitchhikers will be flown on a "space available" basis.

The first Spartan flight is scheduled to be flown in June 1985, and will focus on x-ray astronomy. Three flights of the Spartan are manifested in calendar 1986.

Question 18: This report recommends that NASA initiate a budget for the development of low cost, frequently flown instruments, beginning with several million in FY 1985 and growing to $25M in several years. How realistic is this recommendation? Does NASA intend to initiate such a program? If so, when and what will be the likely funding profile?

Answer 18: The recommendation for new emphasis on low cost instruments is valid, however we question the details of the report. It is NASA's intention to provide this emphasis, consistent with a balanced program in each scientific discipline.

The development and flight of low cost instruments, flown on Hitchhikers, Spartans, and in GAS cans, as well as in the STS middeck and in conjunction with Spacelab missions, has been underway for almost a decade. The currently planned funding profile for this category of instrumentation is a level-of-effort activity at approximately $10-15 million per year.

Question 19: One finding of this report is that with modest modifications and enhancements of existing hardware, including both intermediate class carrier systems and Spacelab, NASA can increase flight opportunities and broaden significantly the scope of research enabled by the Shuttle. Have you considered making any of the recommended changes? If not, why? If so, when will you initiate these changes and how much will these changes cost?

Answer 19: Certain of the report's recommendations have been in our plans for a long time. These include more frequent flights of the Instrument Pointing System, and a 1 arc minute "coarse" pointer (now under development for flight in 1988). The other recommendations are currently under review, including estimation of cost and schedule requirements and technological feasibility.

Question 20: In 1978, NASA selected 40 investigations for Spacelab missions. Only about 20 of these are presently in development or near the start of development. I understand, however, that NASA is reevaluating these Spacelab investigations. What is the nature and status of this reevaluation? What has delayed the development of the "other 20" investigations? How many of these "other" investigations do you intend to develop and over what period of time?

Answer 20: The reassessment of the 40 investigations selected in 1978 for further definition or for development as part of AO-OSS-78-2 is very nearly complete. Our intent was to reevaluate the continuing scientific relevance of all of the proposed investigations, to review the resources required for development of each investigation, and to determine which investigations could be accommodated within the resources and planned flight rates over the next 5 or 6 years. Of the 32 investigations originally selected for development, we now have a plan to accommodate 24 on a variety of missions. The remaining investigations selected for development, plus the 8 investigations selected were deemed to be of lower scientific priority or relevance and we currently do not plan to pursue them further.

Question 21: NASA requested $12 million for Gravity Probe-B for FY 1986, but OMB denied this request. How will this impact Gravity Probe-B? How does NASA plan to keep the Gravity Probe-B program intact through FY 1986? How long can the GP-B program continue to function in its present mode, before it is significantly affected, possibly to the point that the scope of the program has to be reduced?

Answer 21: The impact on GP-B of the reduction is a delay in the Shuttle Demonstration Test Flight program. NASA plans to continue the GP-B technology efforts during FY 1986 at a funding level that should maintain the core of the engineering and scientific staff ($5-6 million). The scope of the GP-B effort will be maintained to the level necessary to satisfy the program scientific requirements.

Question 22: In order for your Comet Rendezvous program, the first in a series of Mariner Mark II programs, to achieve its rendezvous with the Comet Wild-2 in 1995, how critical is it that this program obtain a new start approval in FY 1987?

Answer 22: The CRAF mission should be initiated in FY 1987 to allow sufficient time and resources to support a launch in March 1991 and rendezvous with WILD-2 in January 1995. The next launch opportunity for a WILD-2 rendezvous would be six years later, 1997, for a 2001 rendezvous.

Question 23: Could the program objectives be met if the program were initiated later than FY 1987?

Answer 23: The CRAF objectives could be met if the mission were initiated later than FY 1987. However, the associated funding profile and development risks give us some concern. Other potential comet missions would require about 2-year VEGA trajectories which would add 2-3 years to the spacecraft flight time prior to actual rendezvous with a comet.

Question 24: What will your course of action be if the Comet Rendezvous program is not initiated in FY 1987?

Answer 24: The Solar System Exploration Committee (SSEC) has identified the Comet Rendezvous/Asteroid Flyby (CRAF) as the highest priority new start following the Venus Radar Mapper and the Mars Observer, approved as new starts in FY 1984 and FY 1985, respectively. It is our intent to implement the missions in the priority order recommended by the SSEC. If CRAF is not approved as a new start in FY 1987, it is our intent to select a new cometary target consistent with new start approval in FY 1988.

Question 25: When is the next opportunity for a comet rendezvous if the Wild-2 opportunity is missed?

Answer 25: If the Wild-2 opportunity is missed, the next opportunity for a comet rendezvous would be almost a year later in December 1995 with Comet Kopff.

Question 26: Do you have any doubts about achieving this rendezvous?

Answer 26: While there are still some technical/operational issues to be resolved, there is no doubt about our technical readiness to undertake the mission and to successfully rendezvous with a short period comet.

Question 27: Do you plan to use the West German propulsion module, and, if so, what are the cost savings associated with this choice of propulsion module?

Answer 27: Our current plan asumess use of a West German supplied propulsion module on the CRAF mission. We estimate it will cost the Federal Republic of Germany approximately $25M to develop the module, at an equivalent saving to the U.S.

Question 28: I understand that both AXAF and SIRTF are in their respective Phase B stages. Could you tell us the status of each program and when you expect to initiate development of and to launch each program?

Answer 28: Phase B studies for AXAF are currently underway and scheduled for completion in 1986. The scientific instruments/investigations for AXAF have recently been selected for definition. AXAF will be considered as a potential candidate new start in FY 1987, with an assumed launch in 1992.

SIRTF scientific instruments/investigations have been selected and definition studies are currently underway. Phase B studies for SIRTF are planned for FY 1987-88 leading to SIRTF being a potential new start candidate for FY 1989 with an assumed launch occurring in 1994.

Question 29: Since there are no critical "windows of opportunity" associated with either program, what pressure is there to ensure that these programs are initiated in a timely manner?

Answer 29: Both AXAF and SIRTF would capitalize on U.S. expertise and technology developed on previous x-ray (Einstein Observatory--HEAO-2, launched in 1978) and infrared (Infrared Astronomy Satellite--IRAS, launched in 1983) satellite programs and to maintain U.S. scientific leadership in x-ray and infrared astronomy. Both AXAF and SIRTF offer 100 to 1000 fold improvement in sensitivity over the precursor HEAO and IRAS missions. Together with the Hubble Space Telescope (HST) and Gamma Ray Observatory (GRO) programs, SIRTF and AXAF would complete a complement of astrophysical observatories spanning the electro-magnetic spectrum. Launching AXAF and SIRTF in the first half of the 1990's, when HST and, possibly, GRO will still be operating, will allow unprecedented joint observatories of astronomical sources in multiple spectral bands.

Question 30: I understand that the Earth Observations Mission-1 (EOM-1), which was scheduled for a November 1985 launch has now been rescheduled as an August 1986 launch, as a combined mission with EOM-2. Will this delay jeopardize the planned participation of ESA, Japan, France and Germany in EOM-1?

Answer 30: Our foreign partners in the EOM-1 mission have indicated no change in their planned participation in the mission.

Question 31: What additional costs are associated with this delay?

Answer 31: The cost associated with the EOM-1 mission delay is approximately $2M; however, overall costs for EOM-1/2 have been reduced, due to the fact that, instead of flying two separate missions, we are now flying one.

Question 32: I understand that the Navy's N-ROSS program is experiencing delays of at least six months. What is the full extent of these delays and how will these delays affect NASA's contribution of the Scatterometer to the N-ROSS program?

Answer 32: The Navy has recently annnounced a launch slip for N-ROSS of 15 months (from mid 1989 to September 1990). The primary impact to NASA is a delay in the delivery of the Scatterometer instrument to the satellite contractor by 13 months.

Question 33: NASA's budget request provides $31.7 million for the Scatterometer. How and to what extent will the delay in the N-Ross program affect NASA's FY 1986 requirements for the Scatterometer program?

Answer 33: With the recently announced launch slip of N-ROSS, the Navy has indicated that the new delivery date for the NASA scatterometer is January 1989, some 13 months later than originally planned. However, many commitments have already been made towards the development of the Scatterometer by NASA, based on the earlier delivery date of December 1987. For example, a firm-fixed price contract has already been awarded to Hughes for the transmitter.

Harris has been selected as the antenna contractor, and negotiations are beginning with General Electric for the radio frequency subsystem. The effect of these actions is to obligate NASA contractually to build the major elements of the Scatterometer to a schedule consistent with a December 1987 delivery. To do otherwise is to invite serious cost overrun. It is our belief, based on a preliminary analysis of the situation, that it would be best to build the Scatterometer to the schedule that existed at the time of program approval in order to minimize total program costs. Therefore, we do not foresee any effect on the FY 1986 funding requirements as a result of the N-ROSS launch delay.

Question 34: I understand that Spacelab Life Sciences-1 (SLS-1) has been removed from the manifest from its previously scheduled launch date of January 1986. When will SLS-1 be flown?

Answer 34: The SLS-1 launch date is currently under review due to Shuttle manifest changes; another calender year 1986 launch opportunity is currently being pursued. SLS-1 can be manifested as early as April 1986 and as late as August 1986 without impacting downstream missions from a technical point of view, however; there would be a budgetary impact. This impact has not yet been fully defined.

Question 35: Since SLS-1 is NASA's first dedicated Life Sciences Spacelab, how, and to what extent, will this delay affect the development of life sciences research data that is critical to the space station program?

Answer 35: NASA has conducted some Life Sciences experiments on all of the Shuttle missions to date. Therefore, Life Sciences research is being continually conducted. While the dedicated Life Sciences missions are a critical element of understanding the long term effects of weightlessness on human beings, we do not anticipate a major impact to the space station program as a result of delaying the first dedicated Life Sciences mission.

Questions of Senator Riegle and the answers

Space Science and Space Station

Question 1: Based on your experience with NASA and with the Task Force on the Scientific Uses of the Space Station, are you confident that the space station will benefit science?

Answer 1: Our future Space Science and Applications programs can benefit greatly from the establishment of a permanent manned Space Station in the 1990's, and we are already studying the possibilities in considerable detail. Such planned elements of the Space Station as pressurized laboratory modules, servicing accommodation and workshop facilities, and major polar orbiting platforms for coordinated Earth observations will make possible more ambitious activities in many fields of investigation. Many of our ongoing programs have already demonstrated the need for future long-term orbital observations, large power supplies, and high data rate capabilities that could be provided by the Space Station and its associated platforms.

Question 2: How will the recommendations of the Task Force and those of the Space Science board of the National Academy of Sciences be incorporated into NASA's definition, design and development of the space station architecture?

Answer 2: We have recently forwarded to the Office of Space Station within NASA a preliminary mission plan identifying space science and applications requirements. This plan, reflects close coordination with relevant NASA advisory groups. For example, before submission of our proposed plan, we reviewed this plan with the Space and Earth Sciences Advisory Committee's Task Force on Science Utilization of the Space Station ("Banks Committee") to assure that we had adequately covered their concerns and recommendations.

Question 3: How will your Office's mission plan for the initial space station complex be incorporated into Phase B? How do your recommendations compare with those of the Task Force and the National Academy of Sciences?

Answer 3: The plan, referenced in the answer to Question 2 along with an associated set of engineering parameters, is to be transmitted to the Space Station "Phase B" design definition contractors, who will use it as a guide as they work out the design and interface concepts for the Station. We recognize that requirements definition is an iterative process, both from the standpoint of establishing space station design and evolving user requirements as the capabilities and limitations of the Station become better known. Periodic reviews of design status and updates of our mission plan are currently defined milestones. In addition, we are maintaining a continuing dialogue with our counterparts in the Space Station organization both at the NASA Headquarters and Center levels. As design proceeds to development, this iterative process will continue, as will the coordination with our advisory groups.

Question 4: When can this Committee expect to see your Science Operations Plan that is meant to be a guide for Phase B studies scheduled to commence in 2 weeks?

Answer 4: OSSA's first operations planning overview will be released to the Phase B contractors through the Space Station Program Office in early May along with other Space Station program materials. This overview will include a conceptual senario of science operations and the more important associated strategies in the conduct of science operations. It will identify the critical operational issues and major study trades that the Phase B contractors should consider in their study activities.

OSSA's approach to science operations planning is evolutionary and iterative with Space Station planning for both Phases B and C. Initial OSSA inputs will be supplied to the Space Station Phase B contractors at formally scheduled requirement update reviews. OSSA's first draft of a comprehensive science operations plan describing how OSSA will conduct science using the Space Station complex will be completed later this year. This draft will be reviewed thoroughly by the community prior to its release and input to the Space Station Phase B Interface Requirements Review scheduled for January 1986. As the Space Station complex design matures through Phase B and Phase C, OSSA's operations planning will be continually updated and will eventually result in an OSSA Operations Implementation Plan for conducting science operations on the Space Station.

Question 5: How many space science and application initiatives are included in the FY 1986 Budget Request that are being developed with adaptation to the space station as a goal? Is the proposed Astrometric Telescope Facility the only project under consideration for space station IOC?

Answer 5: The FY 1986 Budget Request included no major new Space Science and Applications initiatives. However, in virtually every major science and applications discipline, we have identified future candidate missions or payloads which have high potential to take advantage of the unique capabilities of the space station complex in the IOC period. Many of these missions assume adaptation of payloads either developed or under development in our current program. For example, the Solar Optical Telescope, which is being developed as a Shuttle attached payload as part of our current program, is under consideration as a major part of a candidate facility (Advanced Solar Observatory) on the core space station. In addition, the refurbishment repair of ongoing science satellites is being planned through the utilization of the Space station and the current Shuttle/Spacelab payloads requiring long duration space exposure will also utilize the Space Station capabilities. As more information becomes available on the definition and design of the space station, we will continue our investigation of the feasibility of such adaptations. Our reviews will, of course, include cost, engineering, and science trade-offs to assure that overall science and applications objectives continue to be met as effectively as possible.

Trends in NASA's Space Science Program
A September 1984 report--

Question 6: Has OSSA taken any steps to remedy the periodic imbalances in funding that occur between the various disciplines? Will the long-term policy and planning recommendations of the Space Science Board and the National Commission on Space ameliorate this concern?

Answer 6: We do not believe there is an inherent weakness in the periodic imbalance in funding that occurs between the disciplines. Fifteen years ago the space science budget was dominated by the planetary exploration program. Since that time, we started several major new programs in astronomy which have tended to dominate the budget. Recently we started two new planetary projects and have initiated major new programs in Earth Sciences and Applications. The situation is a dynamic one and can only properly be understood by reviewing what happens over an extended period of time.

Question 7: What efforts have you made to increase the OSSA research base as a fraction of your total budget? In light of the costs of OSSA flight projects and the future O&M costs of space observatories, will increases to the research base be possible?

Answer 7: We believe the research base is an important element of the Space Science and Applications Program and have attempted to address this issue in the FY 1986 budget submission which contains augmentations in several portions of the R&A program. We will continue to carefully examine the health of the R&A program and its needs as part of the process of formulating the future fiscal year budgets.

Question 8: How will your office try to balance the mix of free flyer, shuttle and space station science missions?

Answer 8: In formulating the OSSA budget each fiscal year, we go through a comprehensive planning cycle. Our planning activities include internal discussions together with extensive consultation with our advisory committees such as the Space Science and Space Applications Boards, the Space and Earth Science Advisory Committee, the Space Applications Advisory Committee, and the Life Sciences Advisory Committee. These committees provide guidance on major new program thrusts, priorities for new starts within the various disciplines, and recommend the appropriate balance between new starts and the ongoing activities such as the R&A program. We attempt to take as many of these views as is possible into account when we prepare our budget proposal.

Question 9: How does your office address the question of what the relative mix of activities should be between the various space science disciplines to comprise a balanced program?

Answer 9: There is no formula for detemining when a program is in balance and the mix is "right." In annually examining the detailed content of our budget, we look at what activities need to be continued, potential new starts or program augmentations, emerging new areas which need to be fostered, and interplay between work being undertaken in other parts of the program. It is the job of the Office of Space Science and Applications and NASA senior management to ensure that the most pressing needs in all areas of the program are met and that balance is maintained.

FY 1986 Budget Request

Question 10: As you are well aware, the concept of a budget freeze has gained considerable political momentum on Capitol Hill. In light of this fact, could you please advise the Committee as to: the consequences of a freeze on the Space Science and Applications Budget; and how the committee could best rearrange your FY 1986 request to implement such a freeze while minimizing the adverse impact?

Answer 10: A freeze at the FY 1985 level would have serious implications for the Office of Space Science and Applications. We would not be able to carry on the current program at the pace we have planned. Only minor cuts could be imposed on those programs that are getting close to launch, and therefore any large cuts would have to be absorbed by either eliminating or seriously delaying newer programs.

It is assumed that a freeze, if implemented, would probably be directed at NASA as an agency rather than at one particular NASA organizational element such as OSSA. If this were the case, we would have no way of estimating the amount of the cutback that would be assessed to OSSA. Because we have so few programs in the embryonic stage, a sizeable cut would undoubtedly adversely impact some of the established and ongoing programs.

Space Telescope

There is much discussion about the cost overruns associated with the development of the Space Telescope which will be launched next year, as well as its annual O&M costs. As a matter of fact, Mr. Beggs informed this Committee that O&M costs for the Space Telescope would be about $60 million per year and that it would cost an additional $300 million over the first four years of the program to acquire necessary spares.

Question 11: Would you please give the Committee a status report on the Space Telescope, in particular the situation concerning the Fine Guidance Sensors, the software, and the Wide Field Planetary Camera? Is this project still on schedule?

Answer 11: A problem was encountered with the Hubble Space Telescope (HST). Fine Guidance Sensors in that a number of folding mirrors have had to be remounted and their supporting structure increased in stiffness in order to prevent their deformation under assembly loads. While these sensors are behind schedule, we believe the fixes have been identified and they will be delivered to Lockheed by their need date to support a second half 1986 launch readiness. The HST software has also been running behind schedule, but we believe the problems are understood and should not impact the launch schedule. A fix has been identified and is being implemented for the Wide Field Planetary Camera detector array problem; if not fixed, this problem could have resulted in a variation in the quantum efficiency, thus having a serious impact on the instrument's performance. The fix that has been identified, will periodically flood the focal plane with ultraviolet radiation and restore the instrument to its original anticipated performance.

While the Hubble Space Telescope has encountered many difficulties since initiated, we are now entering the overall system integration and testing phase. The HST is still on schedule for launch in the second half of 1986 and is within the runout cost estimate of $1,175M.

Question 12: What percent of the Space Telescope O&M costs are borne by NASA? What percent of the operating costs of the Space Telescope Science Institute at Johns Hopkins are borne by NASA?

Answer 12: All the cost of the HST Operations and Maintenance costs are borne by NASA; the HST Operations costs include the total operating cost of the HST Science Institute at Johns Hopkins.

Question 13: Don't the O&M costs associated with the establishment of scientific observatories in space preclude additional new starts in the out-years and reduce OSSA's ability to support basic science research? What are the total costs associated with development and operation of the Space Telescope for 20 years?

Answer 13: The runout cost estimate for the Hubble Space Telescope development is $1,175 million. The HST Operation Costs are estimated to be on the order of $50-60M per year in FY 85 $'s for the life of the system. We do not believe that the HST operation costs will preclude the initiation of future new starts. It is important to realize that the Hubble Space Telescope spacecraft and optical assembly is a facility which will be used by astronomers, both present and future, as a location for instruments that will be changed throughout its lifetime. The selection, design, and development of these "next generation" instruments are a key part of the future OSSA program.

Question 14: Does the Space Telescope require an Orbiting Maneuvering Vehicle (OMV) for in-orbit servicing and reboosting? What other payloads in your office, if any, require this capacity?

Answer 14: The Hubble Space Telescope will utilize the Orbiting Maneuvering Vehicle (OMV) for reboosting purposes. The OMV can also be utilized for retrieving the Gamma Ray Observatory so that it can be refueled; for delivery of the future platforms to their desired orbit, for servicing unmanned platforms of the future Space Station; to augment the performance of the STS in low earth orbit; etc.

Solar Optical Telescope

The FY 1986 Budget Request includes a substantial increase for the Mars Observer Mission, a FY 1985 new start, and for the Solar Optical Telescope (SOT).

Question 15: Would you please explain to the Committee why the SOT program is still funded in the Spacelab budget? Doesn't a $20 million increase and a $30 million program justify a separate line item?

Answer 15: The SOT has been in the definition phase since 1979 carried under the Physics and Astronomy budget line Spacelab Payload Development and Mission Management. Two generic classes of Shuttle/ Spacelab instruments are included in this activity: (1) Multi-User (Facility) Class Instruments: characterized by broad science capability, several principal investigations and a large user community; and (2) Principal Investigator Instruments: instruments proposed for a specific investigation by a single investigator. The SOT is a facility class instrument which was originally conceived by a Spacelab Facility Definition Team, formed in 1975 in response to the anticipated opportunity to be provided by the Shuttle/Spacelab. The defined capability of the SOT has remained unchanged since 1979, namely to construct a multi-user facility with a very high resolution 1.25 meter telescope which will accommodate an assortment of focal plane instruments that will operate from ultraviolet through near-infrared wavelengths. SOT will study phenomena on the surface of the Sun that have structures smaller than 100 km in size — a major enhancement over current capability — that are considered critically important to the understanding of stellar atmospheres. The SOT is currently the only facility-class instrument in the Spacelab Payload Development and Mission Management program.

The earliest preliminary cost estimate given to the Congress for SOT was a range of $150-250 million (in early 1982). This cost range assumed a launch in late 1988. Since that time, the launch has been delayed to mid-1991 with a runout cost range of $300-350 million.

One could argue that the SOT funding level justifies a separate budget line; however, NASA chose to keep SOT within the Spacelab Payload Development and Mission Mnagement line of the Physics and Astronomy budget line item because SOT was originally defined as a "Spacelab" payload. It is our belief that SOT is still a "Spacelab" payload; thus the reason for carrying the funding for SOT as par tof the P&A Spacelab Payload and Mission Management line.

Question 16: Why has development activity on SOT been allowed to slip from January 1985 to June 1985?

Answer 16: The NASA FY 1985 Budget Request to Congress assumed that the SOT activities would include only definition activities until the Space Telescope Optical Telescope Assembly (OTA) had been delivered to avoid any competition between the ST OTA and the SOT activities within the Perkin Elmer plant. Perkin Elmer delivered the ST OTA in November 1984 but the Fine Guidance Sensors (FGS 1 & 2) which were to be delivered with the OTA are behind schedule and will not be delivered until late Spring/early Summer timeframe.

Question 17: What has caused the cost of this telescope to increase from $75 million to $300 million?

Answer 17: The earliest preliminary cost estimate given to the Congress for SOT was a range of $150-250 million (in early 1982). Since that time, the launch has been delayed to mid-1991 with a runout cost range of $300-350 million. There has been no major cost inverse since 1982 except that initiation of the program was delayed by approximately 3-1/2 years and the estimate has been refined somewhat.

MARS

Question 18: What has caused the nearly 11-month delay with regard to the release of the upper stages RFP for the Mars Mission? What steps has NASA taken to ensure the fact that commercial offerings will be properly considered in this project? Is this mission still scheduled for a 1990 launch date despite these delays?

Answer 18: The delay in releasing the RFP was driven by analysis of and modifications to strategies and approaches in order to assure consistency with policies related to the area of commercialization. Our original procurement strategy needed modification in order to ensure that all the tenets of commercialization were taken into account. Subsequently, extensive modifications were required in both our implementation approach as well as RFP documentation. The final implementation approach is a more complex procurement than originally anticipated.

NASA has tried to ensure that all commercial offerings are considered. We have not "baselined" a specific upper stage for the Mars Observer Mission, but rather have advertized that there will be free and open competition.

The mission is still scheduled for launch in 1990. In order to ensure preservation of that launch date we have advanced the issuance of the science Announcement of Opportunity since instrument selection was the early driver of the schedule.

AXAF

Question 19: An Announcement of Opportunity (AO) was released recently for the Advanced X-Ray Astrophysics Facility (AXAF) on which advanced technology development will commence in FY 1986. Why was the number of instruments selected for AXAF reduced to four from an original level of 8? In an effort to develop economical missions is NASA compromising on the value of the science?

Answer 19: The preliminary planning instrument set for AXAF assumed eight instruments. The selection from the AO was four for the following reasons: (1) The four selected represented what are perceived to be adequate for the highest priority AXAF objectives; (2) in the spirit of a long-life observatory program, other instruments will be phased in at approximately 5-year intervals. Since the x-ray observatory can only use one instrument at a time, this approach should accommodate all AXAF science goals.

Science Payloads

Question 20: There has been much discussion of the potential sale of the data obtained by the Large Format Camera during shuttle flight 41-G. I was pleased, therefore, to hear that within a month NASA expects to release an RFP to select a commercial distributor for this data.

Should I interpret NASA's decision to issue an RFP to mean that the "censorship"/"open skies debate" has been resolved? Please give this Committee the basic principles that influenced your decision and discuss how they will influence future Earth observation missions flown on the shuttle?

Answer 20: NASA's decision to issue an RFP for sale of the Large Format Camera flight film is based on our desire to permit the widest use of experimental remote-sensing data by other government agencies and the private sector. Unlike the long time public distribution of experimental Landsat data through the EROS Data Center, the sale of LFC data products are limited by Public Law 98-365. The operation of the LFC from space comes under the United Nations Outer Space Treaty of 1967, which states that outer space is not subject to claims of national sovereignty, i.e., the open skies principle where outer space shall be free for exploration and use by all states without discrimination of any kind. All of the LFC photography has been released to the EROS Data Center in Souix Falls, SD, for distribution under Section 502 of Public Law 98-365. Prior to this release NASA reviewed the film to determine the geographic location (latitude and longitude) of each data take and the quality of the photography as it related to the camera operation and atmospheric conditions. There was no security review board or censorship review board as has been implied by a number of magazine articles that appeared following the mission. If NASA had observed anything in this film, or in any other space acquired data, that appeared to be of National Security interest it would have been dealt with on a case by case basis. We have been involved in the development and space flight of Earth remote sensing instruments for over 25 years and do not envision any change or restrictions from a security standpoint in future Earth observation missions to be flown on the shuttle or on Earth orbiting satellites.

Question 21: There has been much discussion of the need to accommodate more space science and applications payloads on the Shuttle. Although you address this subject in your testimony, surprisingly you do not reference the Shuttle Science Working Group Report.

Would you please inform the Committee as to what steps your Office has taken to implement the recommendations of the Shuttle Science Working Group?

Answer 21: The report of the Shuttle Science Working Group contained a substantial number and range of suggestions, many of which are considered worthwhile to evaluate in more detail. However, the diversity and number preclude a simple response to your question. We intend to review the findings of the Working Group in some detail, and to determine what aspects would be most effective to pursue. We are in the process of establishing a permanent working group within the Office of Space Science and Applications to provide a continuing forum to address these and related issues.

Question 22: Should a separate $25 million line item be created in the FY 1986 budget to ensure a level of effort budget for intermediate class payloads.

Answer 22: NASA has reviewed in detail the recommendation for a separate line item for intermediate payloads and considers it more appropriate to create some degree of funding flexibility within the Spacelab Payload Development and Mission Management line for this class of payload. In that way, the various Space Science and Applications discipline areas can examine the optimum mixture of payloads to most effectively utilize available resources and to accommodate the broad range of desires of the various science communities.

Question 23: What action has your Office taken to ensure that NASA payloads that have been bumped from the Shuttle manifest for more than six months are given a priority status? When will a final decision by the Administrator be made on this matter?

Answer 23: NASA is currently reviewing the establishment of such a policy.

Senator GORTON. We will now hear from Dr. Fisk, Mr. Rosen, and Dr. Shawhan.

Senator RIEGLE [presiding]. Welcome. Senator Gorton has had to step away to make an introduction in another committee, but let me invite you, Mr. Rosen, to perhaps start out here. Or would you prefer to go in a different order?

Mr. ROSEN. Whatever you wish, Senator.

Senator RIEGLE. Well, I don't know that it matters. I see on the listing that we actually have Dr. Fisk first, then Mr. Rosen, and then Dr. Shawhan, so perhaps we ought to start with Dr. Fisk and then we will just go across the table.

STATEMENTS OF DR. LENNARD A. FISK, JR., VICE PRESIDENT FOR RESEARCH AND FINANCIAL AFFAIRS, THOMPSON HALL, UNIVERSITY OF NEW HAMPSHIRE; MILTON W. ROSEN, EXECUTIVE DIRECTOR, SPACE APPLICATIONS BOARD, NATIONAL ACADEMY OF SCIENCES; AND DR. STANLEY D. SHAWHAN, CHAIRMAN, SHUTTLE SCIENCE WORKING GROUP, OFFICE OF SPACE SCIENCE AND APPLICATIONS, NATIONAL AERONAUTIC AND SPACE ADMINISTRATION

Dr. FISK. Thank you very much. I appreciate this opportunity to talk with you about the proposed fiscal year 1986 budget for the Office of NASA Space Science and Applications. I represent the Space Science Working Group of the Association of American Universities. We are a consortium of 21 universities across the Nation which are actively involved in space science research.

The first reaction to the proposed budget of the Office of Space Science and Applications is a sense of relief. This is unlike previous years when I and my colleagues have testified before congressional committees. There are no proposed reductions in parts of the research and analysis program. There is no immediate crisis for which we must request congressional help.

I would like to add that in these previous years of crises, we have indeed received help from Congress for which the space science community is very grateful.

Rather, the proposed fiscal year 1986 budget provides adequate funding to continue on schedule the programs that were approved in previous years. The Upper Atmospheric Research Satellite, the Mars Observer, the Venus Radar Mapper, the Hubble Space Telescope, the Gamma Ray Observatory, and Ulysses which was previously the International Solar Polar Mission, have all received funding necessary to keep them on schedule for launch.

There are also increases proposed for the mission operations and data analysis funds which will allow for the proper preparation of the Hubble Space Telescope and which will provide for the analysis of data from recent successful missions such as the Earth Radiation Budget Experiment [ERBE] and the Active Magnetospheric Particle Tracer Experiment [AMPTE].

And I would like to note also that there are small increases proposed in all the research and analysis budgets. Although they are generally less than inflation, these increases are viewed, nonetheless, as a welcome attempt to preserve the buying power of these funds.

However, before we become euphoric with the feeling that NASA did well in these times of fiscal restraint and budgetary reduction, we should recognize that there is nothing new proposed in this budget. There are no new starts for scientifc space missions, and there has been no attempt to redress the historical decline in research and analysis support which during the last decade has reduced these funds to a fraction of their former buying power.

Indeed, there is an important conclusion here. Although the proposed budget does show an increase over fiscal year 1985 funds, it only continues previously approved programs along their planned funding track.

The converse is also true. If the proposed funding is not provided, these previously approved programs for which there has already been a considerable investment of time and money, will be disrupted, delayed, or canceled.

We urge you to fund the Office of Space Science and Applications at least at the proposed budget level so that no disruption in ongoing programs will occur. We urge you also to be concerned about this lack of new starts for scientific space missions in the proposed budget. Space missions take more than a decade to execute from the development of their initial concept, through detailed planning, through new start authorization, through fabrication, through launch, to the collection of scientific data.

There are many well-planned missions now waiting in the queue for new start authorization. The Ocean Topography Experiment [Topex] and the International Solar Terrestrial Program [ISTP] are all ready for new starts, and the Gravity Probe-B Experiment [GP-B] is ready for a flight demonstration. The plans for these missions are completed and many of the investigators have been chosen.

The comet rendezvous/asteroid flyby, the avanced x ray astrophysics facility, and several other missions are now nearing the end of their detailed planning stages. These are the missions that will make important scientific discoveries in the 1990's.

We need to improve these missions for new starts at a rate of about one or two per year, which has been the historical rate. A rate of one or two per year will ensure that there is an orderly progression of scientific missions. It will ensure that missions do not remain an inordinately long time in the planning phase. It will ensure that several missions of equal scientific importance are not all competing for the limited new start funds in any 1 year, and will ensure that progress can be made in all the various disciplines of space research.

An orderly progression of new starts now will provide for orderly progress in space science research in the 1990's.

There is also another aspect of future space research which is of particular concern to universities, and that is the development of new concepts and ideas that will service the foundation of future space research activities and the education of the next generation of scientists and engineers.

Universities play a special role in the Space Program. We generate many of the new instruments which will ultimately be flown on space missions. We develop many of the new theoretical concepts. In the process of doing this research, we train the next generation of scientists and engineers.

Unfortunately, there are fundamental problems in the support for university space research which makes our job difficult, and as a consequence leaves the future of the Nation's Space Research Program in doubt.

To develop new instrumentation requires frequent flight opportunities. You must be able to test the instrument on a low cost short duration mission before committing it to a major flight program. Similarly, graduate students being educated in experimental space science need flight opportunities in which to participate. They need hands-on experience. This experience is not possible in satellite projects which are very expensive and which take generally more than a decade to execute which is about twice as long as the typical 5-year graduate career.

Rather, to develop instrumentation and to educate students requires frequent flight opportunities on the shuttle or on rockets and balloons. The shuttle, with its get-away-specials and hitchhikers and Spartans, was supposed to provide this opportunity, but for the most part has yet to live up to its promise.

We understand that NASA is currently planning to increase the availability of such flight opportunities and we indeed hope that these plans bear fruit.

Laboratory equipment at universities is antiquated. We are doing our research and training the second generation of scientists and engineers with equipment from a previous generation. One of my faculty members joked the other day, when asked whether or not a student from a Third World country would be able to work in his lab, and he commented he would do just fine because all the equipment would be familiar.

There is a clear and present need to upgrade university laboratory equipment to make it the best available. The National Science Foundation and Department of Defense have recognized the need to upgrade the equipment for university groups doing research in their programs. And NASA should also be funded to undertake to correct this problem for its university research groups.

There is also a need to provide fellowships to attract the best graduate students into space research. Training in space science is applicable not only to space research, but also to other areas of high technology. NASA has recently expanded its graduate student researchers program to provide financial support for graduate students at universities. We applaud this effort and urge that it be expanded so that there is indeed a next generation of students well trained to meet the challenges of the future.

Many of the problems I have cited are simply a statement that research and analysis funds, which provide much of the basic underpinning for university groups, are no longer adequate. Over more than a decade, there has been a steady erosion in the buying power of research and analysis funds, an average rate of about 3 percent per year, with a commensurate reduction in the capability of universities to perform their vital role in the Nation's space science effort.

The cost of providing frequent flight opportunities, for upgrading laboratory equipment, and for generally increasing support for space research at universities is not excessive when compared to the overall NASA budget. But we fully recognize that it may be difficult to address this year in these times of fiscal restraint.

We urge you, however, to consider the various reports that have documented the needs in these areas. The NASA Advisory Council Shuttle Science Working Group Report and the Report of the NASA/University Relations Study Group have documented what the problems are and the cost of the solutions.

We are seriously concerened about long-term consequences of short-term budgetary decisions and the consequences on research and training capability of our space programs. The university infrastructure on which we are basing the future of the Nation's space research effort is in trouble. It is a long-term problem that has been building up for years, but sooner or later it will have to be addressed.

In my written remarks, I have included a copy of our report statement on the fiscal year 1986 budget which provides more details on the points that I have tried to make. I thank you for this opportunity to talk to you, and I would be happy to answer any questions.

[The attachments follow:]

THE SPACE SCIENCE WORKING GROUP'S STATEMENT ON THE FY 1986 NASA SPACE SCIENCE BUDGET

INTRODUCTION

NASA's space science programs are a source of great pride to the United States. They have brought this country worldwide recognition for its scientific and technological leadership. The unknown frontiers of space provide challenges to scientific inquiry which result in spectacular discoveries. These discoveries in turn stimulate the development of new technologies which strengthen our national security and increase our industrial productivity. Our future leadership and economic prosperity are dependent upon the vigor of our research and technological efforts today and NASA's space science programs are at the forefront of that effort.

Universities are and will continue to be a vital component of the United States space science program. University scientists perform basic space science research--they pose fundamental questions to be answered by NASA missions. In the process, university scientists train the succeeding generation of space scientists and engineers. The interaction at universities between scientists working in the space program and their colleagues in a variety of disciplines provides a source of new ideas for the NASA program and facilitates the incorporation of the space program's results into the mainstream of the nation's scientific and technological base.

SPACE SCIENCE IN THE PROPOSED BUDGET

The proposed budget for the Office of Space Science and Applications would continue the funding of several programs which will make 1986 an exceptional year for space science. 1986 will see the launches of Galileo to Jupiter, the International Ulysses mission to view, for the first time, the Sun from high heliospheric latitudes and the Hubble Space Telescope to conduct astronomical investigations never before possible from ground observatories. In addition. the Voyager 1 spacecraft will encounter Uranus on its trip out of the solar system and Halley's comet will be studied from ground and Shuttle-based telescopes.

The growth in funding from FY 1985 is primarily due to planned increases to execute previously approved missions such as the Upper Atmospheric Research Satellite, the Mars Observer, and the Venus Radar Mapper. Increases in Mission Operations and Data Analysis (MO&DA) will prepare for the the soon-to-be-launched Hubble Space Telescope and provide for analysis of data from recent successful missions such as Earth Radiation Budget Experiment (ERBE) and Active Magnetospheric Particle Tracer Explorer (AMPTE). It is notable that for the first time in several years, NASA is proposing increases for all of the Research & Analysis budgets. These nominal increases will offset, in part, reductions in purchasing power due to inflation.

- The Lack Of New Starts

While the proposed budget will continue to fund those programs which are in place in the FY 1985 budget; it provides no new scientific mission starts. The lack of even one new start this year interrupts the orderly advance of the U.S. space science program and represents a curtailment in our national program. One important measure of the program's vigor is the rate of new starts, normally one or more in a given year.

"New start" status for a mission is a milestone in the orderly progression of a program. It occurs after the mission has been studied and planned by scientists and contractors. and in some cases, after teams of investigators have been selected. Already. the queue of science missions is backed up. with some high-priority projects having been deleted or postponed for years.

Much of the fundamental research conducted in NASA space science programs is linked budgetarily to space missions. Delays in funding can disrupt research and training far beyond the duration of those delays. Research teams--and the programs of research and graduate education they conduct--must be assembled carefully over time; once disrupted. they cannot easily be reassembled.

- The Proposed Budget Fails to Address the Needs of the Space Science Program Infrastructure

NASA's space missions, which receive so much public attention, stand on a broad infrastructure of scientific research and training activities conducted primarily at universities and NASA centers. The success of the missions depends greatly on the condition of these activities, which we note, have suffered a slow erosion over time. The proposed FY 1986 budget fails to address the structural deficiencies. These deficiencies--including growing obsolescence of laboratory and other research equipment and facilities, and inadequate support for graduate students, constitute an accumulating deficit. Once that structural deficit falls below a certain critical mass, our capacity to respond to new challenges is severely weakened. We are rapidly approaching that point.

The Space Science Working Group is extremely concerned that the Administration's FY 1986 budget for NASA reflects short-term budgetary decisions that may generate unintended but irreversible policy consequences for U.S. leadership in space science. While the proposal does not present an immediate crisis, it is another budget which fails to address the basic structural needs thus continuing the slow erosion of the space science research base.

The following paragraphs describe four fundamental aspects of the NASA research base program which are in need of substantial strengthening over time.

FREQUENT, LOW-COST FLIGHT OPPORTUNITIES: The development of new instrumentation for NASA's programs and the training of students require frequent, low-cost flight opportunities. New instruments need to be tested on short Shuttle flights and on suborbital flights before being placed on expensive, long-duration missions. Graduate students need the "hands-on" experience of designing, building, and flying a low-cost payload. In addition to the essential education. these flights produce significant results which sharpen the scientific questions to be answered in major spaceflight programs.

The Shuttle is supposed to provide frequent flight opportunities through "get-away specials," "hitchhikers," and free-flying Spartans. However, this aspect of the Shuttle program has yet to be fully realized. The NASA Advisory Council Shuttle Science Working Group Report (September. 1984), identifies further steps that are necessary to increase and simplify flight opportunities for science and technology on the Shuttle.

Aircraft, sounding rockets, and balloons in the suborbital program provide low-cost. low-risk. and quick-turnaround flight opportunities. This program has been a mainstay of instrument development and graduate student participation in the space program since its inception and will continue in this role for the foreseeable future. The suborbital program is a low-cost, high-leverage component of the NASA effort which should receive continuing support.

RESEARCH LABORATORY EQUIPMENT: Much university laboratory equipment for space research is out of date. With declining purchasing power of Research and Analysis funds, new equipment cannot be purchased. Much current research and graduate students' training is being conducted with equipment from a past generation impairing the quality and productivity of research and training programs.

The need to upgrade university laboratory equipment has been recognized by the National Science Foundation and the Departments of Energy and Defense, which have initiated targeted programs to address the needs. NASA should undertake a similar program, as was recommended in the Report of the NASA/University Relations Study Group (July, 1983).

GRADUATE EDUCATION: Universities train the future generations of scientists and engineers--the talent that will provide the new ideas in space research and will apply the knowledge generated by that research to problems in other technological fields. NASA has recently established a new component of its Graduate Student Researchers Program which will provide financial support to graduate students at universities studying in fields relating to space science. We commend NASA for this promising effort to attract the best students to pursue careers in space science. We urge NASA to expand the program to support the increasing numbers of talented students needed for future challenges.

RESEARCH AND ANALYSIS: NASA's Research and Analysis programs provide the underpinning for all space research at universities. These programs support the development of new instruments and mission concepts. the analysis of data from ongoing missions, the analysis of data from completed missions. the development of theoretical ideas and models, and the education of graduate students. The July 1984 Report of NASA's Space and Earth Science Advisory Committee on Research and Analysis in Space and Earth Sciences said, "It cannot be emphasized too strongly that the quality of NASA's scientific program and the return that the country receives from its investment in space missions, directly depends upon the effectiveness, the health, and the vitality of the Research and Analysis Program."

The funding for Research and Analysis has not kept pace with inflation, nor with the growing breadth of scientific disciplines involved in the space program. Indeed, a recent analysis by the NASA Space and Earth Sciences Advisory Committee reveals a steady decline, in adjusted dollars, of about 3% per year in space science R&A programs since the late 1960's. The Research and Analysis portion of the budget for the Office of Space Science and Applications must be funded to recover some of this loss and to provide real growth in the level of research. Research and Analysis activities should be given a priority commensurate with that of the flight programs.

SOLUTIONS TO THE LONG-TERM PROBLEMS

Several panels have issued recommendations for addressing these long-term problems.

> --The Space and Earth Sciences Advisory Committee has recommended a $30M increase in Research & Analysis to alleviate the problems in these program areas.
>
> --The July 1983 Report of the NASA-University Relations Study Group states that an $11M annual budget is required to upgrade university laboratory equipment. That same report recommends that NASA initiate a graduate fellowship program that will grow after four years to support 200 students. The cost of this program would be approximately $4M per year. (As indicated above, NASA started a new component of its Graduate Student Researchers program in FY 1985, which responds in part of this recommendation.)
>
> --The NASA Advisory Council Shuttle Science Working Group Report (September, 1984), recommends a sustained program of $25M a year to provide essential. frequent flight opportunities on Shuttle. NASA representatives have stated that the proposed FY 1986 budget includes about $3M for this purpose.

CONCLUSION

The Space Science Working Group, is seriously concerned about the long-term effects of these short-term budgetary decisions on the research and training capability of our space science programs. The continuing erosion in U.S. basic space science research represents a loss of investment in our nation's future. Scientific programs and the highly-trained cadre of scientists, which we believe to be important to the future of our nation, take many years to build.

We realize that current fiscal exigencies may require that any solutions to these problems be postponed until after FY 1986. However, we do not believe that it is wise to wait until a crisis is fully upon us before taking corrective measures; by then it will take many years to recover. We urge NASA and the Congress to consider these fundamental deficiencies in the budget. and to begin planning a long-term solution now.

Appendix: Analysis of the Proposed FY 1986 NASA Space Science Budget

APPENDIX: ANALYSIS OF PROPOSED FY 1986 NASA SPACE SCIENCE BUDGET

PHYSICS AND ASTRONOMY

The overall Physics and Astronomy budget of $630.4M decreases by $46.8M from the FY 1985 level. This is due to the planned decrease in funding for the two major observatory programs. Hubble Space Telescope (HST) and Gamma Ray Observatory (GRO), which are now past their peak development phase and are nearing launch (in 1986 and 1988, respectively). The combined decrease for these two programs is $97.1M so that the remaining portions of the Physics and Astronomy budget have increased by $50.3M, which is approximately a 7% increase over FY 1985. The largest part of this increase is for two projects: the Solar Optical Telescope (SOT) ($20.2M), and for HST instrument refurbishment and operations ($13.3M increase). Thus the bulk of the Physics and Astronomy program remains at funding levels which are nearly constant, or at most increased by inflation, from their FY 1985 levels. The following paragraphs summarize the proposed budget for the remaining parts of the Physics and Astronomy program; a budget table is included on pages 6-7.

SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT: These programs are increased by $9.9M over their FY 1985 values in addition to a $20M increase for the previously approved Solar Optical Telescope. Two major Shuttle flight programs are planned for FY 1986: the ASTRO-1 mission for March 1986. and Spacelab 3 to fly later in the year. Other Shuttle missions are under development, and it is expected that a portion of the budget increase in this area will respond to the need by the scientific community for a substantially increased program of low-cost Shuttle experiment opportunities such as represented by the Spartan program.

EXPLORER DEVELOPMENT: These programs are increased $3.3M, which is 6% over their FY 1985 values. This will support continued development on two US Explorer-class missions: COBE for cosmic microwave background studies, and EUVE for extreme ultraviolet observations. NASA will deliver a high resolution x-ray detector to be included on the German x-ray telescope ROSAT scheduled for a shuttle launch in 1987. A re-flight of the Long Duration Exposure Facility (LDEF) for cosmic ray studies is also planned for 1986. No new starts in the Explorer program are planned for FY 1986 although definition studies will continue on possible future Explorers such as the X-Ray Timing Explorer (XTE) and the Far Ultraviolet Spectroscopy Explorer (FUSE).

MISSION OPERATIONS AND DATA ANALYSIS: These programs are increased by $10.8M over their FY 1985 values, largely for increased costs for HST as the launch date in 1986 approaches. Much of this increase is for the development of second generation instruments for HST. The extended mission for the Solar Maximum Mission (SMM) also accounts for a $2.8M increase, while support for the High Energy Astronomy Observatory (HEAO) and Explorer data analysis programs is decreased.

RESEARCH AND ANALYSIS (R&A): This budget is increased by $2.4M over FY 1985, a 6% increase that is essentially constant funding in real dollars. The modest increase in the R&A line is welcome but will be absorbed largely by the definition studies for the Gravity Probe-B mission. The new Astrophysics theory program initiated last year will be maintained at the current level. The Advanced Technology Development (ATD) program will provide minimal support for the definition and design studies for the highest priority candidate future astrophysics observatory missions, the Advanced X-Ray Astrophysics Facility (AXAF) and the Space Infrared Telescope Facility (SIRTF). Both missions have gone through the instrument selection phase but low funding levels are presently only sufficient for Phase B definition studies for AXAF.

SUBORBITAL PROGRAMS: These programs, vital for the development of future space missions, are increased by $3.7M, or approximately for inflation. The anticipated number of balloon flights will be increased, and the sounding rocket program will continue to be phased into the Spartan program with two new Spartan experiment development efforts to be initiated.

PLANETARY EXPLORATION

The requested Planetary Exploration budget of $359M represents a continuation of ongoing programs that were started in previous years, with no new initiatives or program augmentations. The increase of $68.1M over the FY 1985 budget results largely from the normal spending histories of mission projects, which reach peak spending levels several years after a project starts. The major budget changes from last year are in the Venus Radar Mapper (VRM) and the Mars Observer (MGCO), both of which are approaching peak spending years. Galileo development is diminishing as it and approaches launch in 1986. Increases in the Mission Operations and Data Analysis (MO&DA) line largely reflect the preparation of the Voyager mission for the Neptune encounter as well as the start of Galileo mission operations. The Planetary Research and Analysis program continues at approximately constant dollars, which is a 4% decrease adjusted for nominal inflation.

The requested budget is a gratifying reflection of the Administration's commitment to rebuild the U.S. Planetary Exploration program back to a vigorous level. This is particularly evident in Research and Analysis (R&A). The proposed R&A

budget is a welcome change from recent crisis years, in each of which substantial decreases were proposed; this year R&A will suffer a modest decrease due to inflation.

The following paragraphs briefly analyze the various major parts of the Planetary Exploration budget, their condition in the proposed budget, and the contributions that these programs make to the nation's overall space science effort.

GALILEO DEVELOPMENT: This project shows a decrease of $16.4M as the development stage draws to completion. Galileo was originally to be launched in 1982, but was delayed four years by development problems, including the absence of an adequate shuttle-based launch capability. The implementation of the Galileo mission to Jupiter marks the start of a new and intensive phase of outer-planets investigation.

VENUS RADAR MAPPER: The Venus Radar Mapper (VRM) increases $19.5M as it enters the third year of development. Due to be launched in 1988, VRM will carry out a detailed geological mapping of Venus' surface. This is an essential step in NASA's detailed study of the triad of terrestrial planets: Venus, Earth, and Mars. Knowledge obtained through these investigations will greatly advance our understanding of the behavior and evolution of terrestrial planets, including Earth.

MARS OBSERVER: The Mars Geochemical and Climatological Orbiter is the first in the sequence of "Observers", a class of relatively low-cost, frequently-launched planetary spacecraft that forms part of the core of the ongoing NASA planetary exploration program. The $30.8M increase in this line reflects continuation of an orderly and controlled development sequence for this mission. This mission will carry out important global investigations of Mars, and is part of the detailed study of the triad of terrestrial planets.

ULYSSES (ISPM): The International Solar-Polar Mission is a "non-planetary" project which is being managed by the NASA planetary division in order to capitalize on the deep-space operations expertise which is unique to that division. Ulysses is being carried out in collaboration with the European Space Agency; it will be the first spacecraft to carry scientific instruments to high heliospheric latitudes, well away from the ecliptic plane, and will make measurements critical to our understanding of the three-dimensional structure of interplanetary space. The $3.4M decrease in that line follows the expected evolution of that project.

MISSION OPERATIONS AND DATA ANALYSIS (MO&DA): This line supports the in-flight operation and data analysis of ongoing planetary missions. The increase of $36.2M reflects the activities needed to accommodate the Voyager encounters with Uranus and Neptune, the onset of Galileo operations, and the other continuing mission operations, including Pioneer and Ulysses. The MO&DA activity is a basic part of the infrastructure needed to support deep-space missions and other planetary projects.

RESEARCH AND ANALYSIS (R&A): This R&A program supports basic research activities in planetary science as well as research and development, and program activities needed to plan future projects. It is from this budget line that the broad planetary research activities are supported in the nation's universities and laboratories. The proposed budget increase of $1.4M is about 2.3%, well below the recently increased costs of carrying out these activities.

ENVIRONMENTAL AND SOLID EARTH OBSERVATIONS PROGRAMS

The Environmental and Solid Earth Observations programs have a number of positive features in the proposed FY 1986 budget. It is gratifying to see that the Upper Atmosphere Research Satellite Mission and the Scatterometer development programs follow their nominal timelines. Inflationary increases are provided for each of the Research and Analysis lines, and indeed in the case of R&A for Solid Earth Observations an augmentation of $4.5M (28%) is proposed. Although no further erosion has occurred this year, it should be noted that some of these R&A lines have still not been returned to funding levels of previous years. A substantial increase is also proposed for Mission Operations & Data Analysis (MO&DA) to accommodate recent successful flight missions such as the Active Magnetospheric Particle Tracer Explorer (AMPTE). Ongoing Shuttle payloads will proceed on schedule with the proposed funding.

SOLID EARTH OBSERVATIONS

The Solid Earth Observations program is budgeted at $74.9M, an increase of $17.3M or 30% over the FY 1985 level. Much of this increase is in the Shuttle/Spacelab payloads line and will go toward advanced spectrometer technology development and study of the next generation of Shuttle Imaging Radar (SIR-C). The Geodynamics Program, including the Crustal Dynamics project, laser network operations, and research and technique development, is budgeted at 6% over FY 1985, an inflationary increase. The R&A line which supports land remote sensing is increased by 29%, a much needed supplement. This area has long been recognized as being one where NASA needs to develop a stronger scientific base.

ENVIRONMENTAL OBSERVATIONS

The Environmental Observations program is budgeted at $317.5M, an increase of 30% over FY 1985 that reflects the expected growth in the Upper Atmosphere Research Satellite and Scatterometer programs. The R&A lines show modest growth of approximately 6% reflecting inflation over the year. Extended mission operations show a modest growth to accommodate the operations and data analysis of recent successful flight missions such as Nimbus-7, the Solar Mesosphere Explorer (SME), and the International Sun-Earth Explorers. The Tethered Satellite Payloads line shows $15M growth in anticipation of instrument development following the initial payload selection.

The principal difficulty for this program area is the lack of new starts. The Space and Earth Science Advisory Committee recommended two new starts in FY 1986, the Ocean Topography Experiment (TOPEX) and the International Solar Terrestrial Program (ISTP), and neither were included in the proposed budget. The problem is compounded by inadequate Advanced Technology Development (ATD) funds for these programs, which will make the orderly study of these missions and the maintenance of their scientific teams difficult. TOPEX's ATD will be funded in the Oceanic Processes Research and Analysis line and ISTP's in the Space Physics Research and Analysis line.

SPACE SCIENCE IN THE FY 1986 NASA BUDGET
(in millions of dollars)

	1982	a/ 1983	1984	1985	Proposed 1986
Total NASA	6020.0	6836.4	7217.5	7510.7	7886.0
Total Research & Development	4772.0	1902.5	2028.5	2422.6	2881.8
Space Flight, Control and Data Communications		3633.0	3775.3	3601.8	3509.9
Total Space Science & Applications	896.2	1034.1	1157.0	1404.5	1613.2
Space Station	-	-	(21.9)	150.0	230.0
Total Physics & Astronomy	322.4	470.3	567.6	677.2	630.4
Space Telescope Development	121.5	182.5	195.6	195.0	127.8
Gamma Ray Observatory	8.0	34.5	85.9	117.2	87.3
Shuttle/Spacelab	47.6	81.0	80.9	105.4	135.5
Explorer Development	33.3	34.3	48.7	51.9	55.2
Mission Operations & Data Analysis	45.3	61.4	68.1	109.1	119.9
Research & Analysis	22.9	28.5	35.8	39.9	42.3
Suborbital	43.8	48.1	52.3	58.7	62.4
Total Planetary Exploration	210.0	186.4	217.4	290.9	359.0
Galileo	115.7	91.6	79.5	56.1	39.7
Venus Radar Mapper	-	-	29.0	92.5	112.0
International Solar Polar	5.0	6.0	6.0	9.0	5.6
Mars Geoscience/ Climatology Orbiter		-	-	13.0	43.8
Mission Operations & Data Analysis	42.6	38.5	43.4	58.8	95.0
Research & Analysis	46.7	50.3	59.5	61.5	62.9
Total Life Sciences	39.5	55.7	58.0	62.3	72.0
Flight Experiments	14.0	24.0	23.0	27.1	33.4
Research & Analysis	25.5	31.7	35.0	35.2	38.6
Total Solid Earth Observations	149.4	128.9	76.4	57.6	74.9
Landsat-4	81.9	58.4	16.8	-	-
Shuttle/Spacelab	12.3	14.5	17.0	12.1	23.1
Geodynamics	22.9	28.1	28.0	29.9	31.7
Research & Analysis	15.5	11.8	14.6	15.6	20.1
Total Environmental Observations	133.0	156.9	162.0	212.7	317.5
Total Research & Analysis	71.8	86.4	90.8	95.6	101.7
Upper Atmosphere	20.5	27.7	28.4	31.0	33.0
Atmosphere dynamics and Radiation R&A	22.3	26.5	27.4	28.5	30.3
Ocean processes	16.9	17.0	18.2	19.4	20.6
Space Physics	12.1	15.2	16.8	16.7	17.8
Shuttle/Spacelab	4.1	3.7	7.6	7.8	5.6
Operational Sat. Improv.	6.0	6.0	0.6	-	-
Earth radiation budget	24.0	24.0	15.5	8.1	2.0
Extended mission ops	16.1	22.8	27.4	29.5	37.0
Interdisciplinary R&A	-	-	-	1.0	1.0
Tethered Satellite Payloads	-	-	-	3.0	4.5
Scatterometer	-	-	-	12.0	31.7
Upper Atmos Research Satel.	6.0	14.0	20.0	55.7	134.0

a/ Shown on a comparative basis with the budget structure changes instituted in FY 1984.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. How and to what extent will TOPEX be affected by the fact that it was not approved for a new start?

How will the French participation in TOPEX be affected?

What is the critical starting date for TOPEX if the French participation is to be maintained?

Answer. The important issue for TOPEX is to fly concurrently with the Navy NROSS satellite and the European Space Agency's ERSI. This requires a launch in 1990. According to JPL, such a launch is possible with a new start in FY 1987. The French have agreed to continue their participation in TOPEX, provided that NASA will seek a FY 1987 new start. Clearly, if a new start were delayed beyond FY 1987, the scientific return from the mission would be seriously weakened and the French participation would be in doubt.

Question. Dr. Fisk, the FY 1985 NASA authorization provided funds for updating university laboratory equipment and instruments and strongly urged NASA to assume a greater responsibility in this area. Yet, your written statement indicates that NASA's budget request is deficient in this area.

To what extents has NASA assumed any of this responsibility of updating university laboratory research equipment?

Are there any institutional barriers at NASA to updating this university research equipment?

If so, what are they and how might they be removed or negotiated?

Answer. Although NASA continues to make supportive statements about the need to upgrade university laboratory equipment, it has not been a priority for the agency. The difficulty is inadequate resources. The Research and Analysis budgets that fund ongoing research are not keeping up with inflation. Over the last decade there has been a decline at an average rate of 3% per year. There have not been enough R&A funds to provide continuity for the supported research and as a result, there is no excess to provide for instrumentation funding. Thus, a dedicated equipment program could be funded only at the expense of other legitimate requirements on Research and Analysis funds. There is a clear need for an infusion of new funds to both restore the buying power of Research and Analysis funds and to allow for a major upgrading in equipment.

Question. Dr. Fisk, NASA requested $12 million for Gravity Probe-B, but OMB denied this request.

What is required during FY 1986 to maintain the scientific integrity of Gravity Probe B?

How critical is it that Gravity Probe B receive an approval for a new start in FY 1987, when one considers all of the other science and applications programs seeking a new start in FY 1987?

Answer. To sustain the Gravity Probe-B effort in FY 1986, approximately $5–6M is required. It is important to note that Gravity Probe-B is not a new start in the same sense as TOPEX and ISTP. Funds are simply being sought for a test flight, which if successful could lead to a more ambitious mission later.

Question. Dr. Fisk, according to your testimony, a rate of one or two science new starts a year will insure that there is an orderly progression of scientific missions.

What programs would your Working Group select as the one or two new starts for the next two years and why?

What is your assessment of the omission of any scientific new starts in this budget request?

Answer. The lack of new starts is the most serious problem in the President's proposed FY 1986 budget for the Office of Space Science and Applications. The systematic development of new missions has been disrupted. Programs that should have been started this year are delayed until next year, and in turn upset the schedule for missions now in the planning stage. The orderly progression of missions that will yield the important scientific discoveries in the 1990's has been upset. As for recommendations on new starts, there are in fact a number of missions that should be undertaken over the next few years. The Space and Earth Science Advisory Committee recommended last year that TOPEX, the oceanography topography mission, and ISTP, the International Solar Terrestrial Program, be ready for new starts. Also, the Comet Rendezvous/Asteroid Flyby, the Advanced X-Ray Astrophysics Facility, and the Space Infrared Telescope Facility are high priorities for new starts in this time frame.

Question. Dr. Fisk, the International Solar Terrestrial Physics (ISTP) program involves participation by ESA and Japan.

In your opinion, when is the critical starting date for this program in order to maintain their participation?

How would this program and the U.S. participation be affected if ESA or Japan left the program?

Answer. The participation by ESA and Japan in the International Solar Terrestrial Program is critical. First, this program is an important example of international scientific cooperation, on problems of worldwide interest. Second, the cost of the program to the United States is substantially less with international participation. Each spacecraft in the ISTP is important for understanding the solar-terrestrial system; under the current plans, the United States needs to provide only three of the spacecraft. However, to maintain the participation of ESA and Japan, a new-start commitment in FY 1987 is required.

Question. Dr. Fisk, you have spoken about the troublesome predicament of our university infrastructure and, in particular, problems as they relate to laboratory equipment, frequent flight opportunities, and graduate training.

Just what are the opportunities that NASA and our nation are missing due to the present state of our university infrastructure, as you have described in your testimony?

How are our present efforts being affected by this condition?

Answer. The space program is vital to the future of the nation. The United States is becoming a spacefaring nation. Our space-research activities today are preparing us for this future. Universities play a vital role in this preparation. We are training the scientists and engineers that will lead us into space in the future. Clearly, if the university infrastructure is inadquate—if our equipment is out of date; there is insufficient fellowship funds; the flight opportunities are infrequent—the nation's future is at risk.

Question. Dr. Fisk, what is your assessment of NASA's progress to date in addressing the concerns of the space acience community relative to space station utilization?

What are the major concerns of your Working Group concerning the space station program's ability to meet the needs of the space science community?

Answer. The Space Station can provide a valuable tool for science provided that: (i) there are unmanned platforms in both polar and equatorial orbit that will accommodate a range of scientific instruments; (ii) the Station and the platforms will provide frequent flight opportunities; (iii) science is adequately developed during the next few years, by using frequent Shuttle Flights, so that we are ready to make use of the Space Station; and (iv) the Space Station is not developed at the expense of the science portion of the NASA budget.

In the ideal case, the Space Station and its accompanying platforms will provide the opportunity to fly large, serviceable instruments for a wide range of scientific disciplines. For example, a polar-orbiting platform will provide an opportunity to do detailed and coordinated remote sensing of the Earth, as is now being envisioned with EOS, the Earth Observing System. Equatorial platforms will provide opportunities for detailed astronomical observations.

It is important, also, that the Space Station itself be designed to accommodate the demands of major scientific investigations, especially for those cases in which the Station may be an important enabling factor. NASA should ensure that the Space Station design, performance, facilities, and services are responsive to the needs of important scientific investigations. The danger is that, as the project progresses, the scientific needs will become submerged to the strong internal pressure that NASA will feel just to get some kind of habitation into orbit.

It is important to realize, however, that the Space Station program will not be helpful to all scientific disciplines. There are important scientific disciplines that require *in situ* measurements in deep space, e.g., the study of the deep magnetosphere and the solar wind, and planetary exploration. An appropriate balance between deep-space free-fliers and Space Station studies should be maintained.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS

QUESTION

Your testimony seems to corroborate the findings of the Shuttle Science Working Group that low cost, frequent flight opportunities are critical to science and technology investigations. Do you have any recommendations as to how the Committee can provide $7.5M in FY 1986 for these activities without exceeding the President's FY 1986 Budget Request? Don't commercial users confront comparable flight opportunity problems? Is there any concern with the Space Science Working Group that budget increases for shuttle science will come at the expenses of the Suborbital Program? How do you balance the various flight opportunity needs and requirements of the space science and technology community (sounding rockets, balloons, shuttle, free-flyers)?

ANSWER

Scientific uses of the Shuttle need to be developed concurrently with the Space Station so that, when the Space Station flies, the science community is ready to use it. As a result, needed extra funds to provide frequent flight opportunities can be considered to be a legitimate charge against the Space Station development.

There is indeed a concern that budget increases for Shuttle science will come at the expense of the suborbital program. There are legitimate scientific reasons for maintaining a large portion of the suborbital program even in the Shuttle and Space Station era. Sounding rockets, balloons, and aircraft provide access to regions not accessible to the Shuttle, and are truly low-cost flight opportunities. The funding level for suborbital programs, and in particular the expertise in the NASA Centers needed to support these programs, should be maintained.

It is important to leave sub-orbital capabilities intact until frequent low-cost Shuttle opportunities have become a proven reality. Otherwise, there will be a hiatus in building and flying new instruments which would have a very serious long-term impact on several disciplines.

A formula on how to balance flight opportunities among rockets, balloons. Shuttle, and free-fliers is difficult to provide. However, two criteria should be followed. There should be systematic opportunities for the development of instrumentation, from suborbital flights, through Shuttle programs, to free-fliers. Second, the flight opportunities should provide for a correct balance among the various scientific disciplines. There are certain fields such as planetary exploration that rely primarily on free-fliers; there are other fields, such as atmospheric and auroral physics, where sounding rockets are particularly important.

QUESTION

As you are aware, the FY 1985 NASA Authorization endorsed the development of a space station. However, the Committee remains concerned that the space station accommodate various "users" concerns. Some of these issues will be explored in greater depth next week at the Committee's Space Station Hearing. Could you please give us your impressions as a member of the science community as to the need of and uses of a space station?

Should a co-orbiting platform be part of the initial configuration, and what scientific uses would such a platform have? Can the Office of Space Science and Application balance the needs of the science community with the demands of the space station? For example, will missions that were formerly free-flyers, shuttle or platform related be diverted to the space station? How can the science community feel comfortable it will have access to the space station when the Shuttle Science Working Group Report indicates how ~~difficult~~ it has been to obtain shuttle flight opportunities?

ANSWER

The Space Station can provide a valuable tool for science provided that: i) there are unmanned platforms in both polar and equatorial orbit that will accommodate a range of scientific instruments; ii) the Station and the platforms will provide frequent flight opportunities; iii) science is adequately developed during the next few years, by using frequent Shuttle Flights and suborbital flights so that we are ready to make use of the Space Station; and iv) the Space Station is not developed at the expense of the science portion of the NASA budget.

In the ideal case, the Space Station and its accompanying platforms will provide the opportunity to fly large, serviceable instruments for a wide range of scientific disciplines. For example, a polar-orbiting platform will provide an opportunity to do detailed and coordinated remote sensing of the Earth, as is now being envisioned with EOS, the Earth Observing System. Equatorial platforms will provide opportunities for detailed astronomical observations.

It is important, also, that the Space Station itself be designed to accommodate the demands of major scientific investigations, especially for those cases in which the Station may be an important enabling factor. NASA should ensure that the Space Station design, performance, facilities, and services are responsive to the needs of important scientific investigations. The danger is that, as the project progresses, the scientific needs will become submerged to the strong internal pressure that NASA will feel just to get some kind of habitation into orbit.

It is important to realize, however, that the Space Station program will not be helpful to all scientific disciplines. There are important scientific disciplines that require _in situ_ measurements in deep space, e.g., the study of the deep magnetosphere and the solar wind, and planetary exploration. An appropriate balance between deep-space free-fliers and Space Station studies should be maintained.

In response to your question as to whether the scientific community is concerned that we will have access to the Space Station when we currently do not have adequate access to the Shuttle, the answer is clearly yes. Let me say, however, that we are at least hopeful that lessons have been learned from the Shuttle experience that will not be repeated on the Space Station.

QUESTION

In September 1984, the White House Office of Science and Technology Policy issued a Report entitled "Funding Trends in NASA's Space Science Program." The Report made three recommendations concerning the space science program's disciplinary mix, research base and long-range planning. What are your impressions of this Report? Can the activities of the National Commission on Space and the National Academy of Sciences related to long-term space science planning, facilitate development of a sustained, well directed space science program.

ANSWER

The report by OSTP on "Funding Trends in NASA's Space Science Program" is an excellent analysis, and the conclusions are, in general, endorsed by the Space Science Working Group. Disciplinary balance, which is one of the concerns of this report, has been a long-standing goal of both NASA and the advisory structure of the National Academy of Sciences. It is important to understand, however, that disciplinary balance requires resources. Each of the major science discipline areas--astronomy and astrophysics, planetary exploration, solar-terrestrial, and earth science--is undertaking increasingly complex missions, which require adequate resources.

It should be noted that the proposed FY 1986 budget shows a strong trend to increasing the fractions of the OSSA budget for Planetary Exploration and for Solar-Terrestrial and Earth Sciences, and decreasing the fraction for Astronomy. This is the direct result of the fact that there has not been a recent new start in Astronomy, but the recently started Mars Observer and Upper Atmosphere Research Satellite are on rising portions of their funding curves. Starts for TOPEX and ISTP, as recommended by SESAC (see answer to question 5 below), will further increase the Solar Terrestrial and Earth Sciences. This is a result of a normal and healthy progression of new starts, and does not appear to require radical efforts to achieve balance. Indeed, without new starts in Astronomy in the next few years, such as AXAF and SIRTF, the Astronomy portion of the budget will fall to unhealthy low levels.

We are particularly pleased to see the OSTP recommendation for increased funding for the Research Base. This has been a consistent theme of testimony from our Group for several years. The erosion of Research Base Support in space science over the past fifteen years has been well documented by the recent SESAC report on Research and Analysis, and this erosion is a serious threat to the long-term viability of our nations space science efforts.

The OSTP suggestions regarding long-range planning are important, and we think it likely that the efforts of the National Commission on Space and of the NAS Space Science Board, as well as the efforts of NASA's SESAC can have a significant role in this planning.

QUESTION

In your testimony, you express a "sense of relief" with the proposed Office of Space Science and Applications budget since it includes "no major reductions" and presents "no immediate crises." Still, the tone is forewarning! Could you please give the Committee your recommendations as to what OSSA missions should be given "new start" status in FY 1987 and FY 1988? With the advent of space observatories such as the Hubble Space Telescope, won't there be added out-year budgetary pressures because of the associated operating, servicing, and maintenance costs of these in-space observatories? How would you recommend implementation of a budget freeze at the FY 1985 level if this Committee is required to do so? What missions could be stretched out with the least adverse impact?

ANSWER

The lack of new starts is the most serious problem in the President's proposed FY 1986 budget for the Office of Space Science and Applications. The systematic development of new missions has been disrupted. Programs that should have been started this year are delayed until next year, and in turn upset the schedule for missions now in the planning stage. The orderly progression of missions that will yield the important scientific discoveries in the 1990's has been upset.

As for recommendations on new starts, there are in fact a number of missions that should be undertaken over the next few years. The Space and Earth Science Advisory Committee recommended last year that the oceanography topography mission (TOPEX) and the International Solar Terrestrial Program (ISTP), were ready for new starts. Also, the Comet Rendezvous/Asteroid Flyby, the Advanced X-Ray Astrophysics Facility, and the Space Infrared Telescope Facility are high priorities for new starts in this time frame.

Clearly, there are concerns that the costs of building and operating the Hubble Space Telescope and other large facilities should not come at the expense of other important aspects of the NASA space science program. It is important to have balance among the various disciplines, so that progress can be made in each field of space science.

BUDGET FREEZE

Your question about a budget freeze at the FY 1985 level is one of particular concern to the Space Science Working Group. It is important to realize that the activities of the Office of Space Science are already frozen in the President's FY 1986 budget. The level of activity is unchanged from FY 1985. There are no new programs proposed, simply the continuation along planned funding curves of previously approved programs. It follows, therefore, that if the budget rather than the activities is frozen, then activities will have to be curtailed.

The delay or cancellation of flight programs has many serious consequences. For programs that are canceled, the investment of taxpayers' money and scientists' time is of course lost. For programs that are delayed, there are major increases in the total run-out cost. Work cannot simply be stopped on flight projects; there are continuing costs even during periods of reduced activity that add substantially to the cost of the mission. Indeed, the least expensive method for developing a mission is to do it quickly. Delays and cancellations of ongoing projects are thus not fiscally responsible approaches, which will contribute to the long-term control of the Federal deficit. It is important to emphasize also that delays in ongoing programs only exacerbate the new-start problem. Delays further disrupt the orderly progression of scientific missions.

The Space Science Working Group appeals to Congress not to freeze the budget for the Office of Space Science and Applications. At the very least, NASA should be allowed to maintain its programs at the level of effort that has been already planned so that there is no reduction in the buying power of its funds. NASA should be required to continue ongoing programs, along their planned funding curves. And every effort should be made to retain the proposed inflationary increases in the Research and Analysis budgets. As I indicated in my testimony, such funds are the lifeblood on the university space-research activities.

Senator RIEGLE. Thank you very much.

Mr. Rosen.

Mr. ROSEN. Senators and members of the committee, on behalf of the Space Applications Board of the National Research Council, I would like to thank you for the invitation to participate in this hearing.

My purpose is to present the thinking of the Board on the space applications program.

I am appearing in place of Dr. John Townsend who is the chairman-designate of the Board, and who regrets that he cannot be here.

Last year we appeared before your subcommittee in support of two major programs. The first of these, the space station, has been approved and is moving forward on a broad front in NASA and its industrial partners. Our report, "Practical Applications of a Space Station," was published in March of last year and expanded upon the testimony we gave to you.

Also last year, we urged reinstatement of the Advanced Communications Technology Satellite Flight Test Program, an undertaking that we had been recommending to NASA for several years. We are pleased to note that this is now an approved program and is proceeding well, owing in large part to the initiative of this committee and the Congress as a whole.

This year the Board's principal concern has been the U.S. program of remote sensing in space, including the roles played by NASA, NOAA, and other government agencies. The Board and its Committee on Practical Applications of Remote Sensing From Space have been studying this situation for a year and a half and are preparing a report that should appear later this year. Nevertheless, it is possible for me to tell you now about the reasons for our concerns.

Remote sensing from space involves observing the Earth with instruments carried in satellites: probing the Earth's atmosphere, which supports weather prediction and climate studies; viewing the Earth's oceans, which has both scientific and practical uses; and observing the Earth's land masses, with its applications to mapping, land use, oil and mineral exploration, agriculture, forestry, and the management of other Earth's resources.

This wide-ranging activity that has been promoted and developed by the U.S. Government for almost 25 years is now in a state of decline and is approaching a critical condition. Other nations now entering this field are not only aggressive competitors, but also threaten our leadership position.

It is important to understand why this is happening and to consider what should be done to reverse the decline in U.S. activity.

In the area of atmospheric observations from space, NASA continues to maintain a strong program in research, the centerpiece of which is the new upper atmosphere research satellite mission. NOAA, however, is responsible for the operation of weather satellites and is having difficulty in maintaining more than one healthy satellite in low-polar orbit and one in geosynchronous orbit. Should either of these satellites fail, our ability to predict weather in the United States and to cooperate in international weather prediction would be seriously impaired.

The meteorological community needs two healthy satellites in polar orbit and two in geosynchronous orbit to fulfill the nation's forecasting expectations. We should not be operating with such a small margin of safety.

As a separate issue from this operational problem, there has developed a serious institutional gap which is of great concern to our Board. In earlier years, NASA designed and operated experimental weather satellites such as Tiros and Nimbus, that developed new instruments and spacecraft and supported the operational weather satellite system.

This activity was planned and implemented by NASA in cooperation with NOAA. In recent years, this excellent working relationship between NASA and NOAA has all but vanished. The current situation poses a serious threat to the future of our weather satellite system.

NASA is no longer actively involved in the planning and implementation of programs that transition new meteorological instruments into operational use. You will ask what should be done to correct this situation and we are endeavoring in our study to find some answers. What we do know is that this institutional gap is serious and needs to be corrected.

The program on ocean observations from space is the last one of the three to be addressed and is moving forward slowly. The Seasat spacecraft,which was operating in 1979, returned data for only a few months, but even so it illustrated the great value of satellite observations of the oceans.

Now two projects are coming into fruition: the first of these, the Navy's N-Ross, is moving forward well. For this project, NASA is developing the scatterometer, an instrument that determines wind velocity and direction from sea state measurements. Our Board is pleased to note that this development is supported in the present budget.

The second future mission is called Topex, the Ocean Topography Experiment, which was to have been a NASA new start this year, but somehow failed to survive the budgetary process. We have been assured by Administrator Beggs that Topex remains high on NASA's priority list and will probably be recommended as a new start next year.

Our major worry, however, is about Landsat, which in our opinion is in critical condition. The Commerce Department has been moving toward a transfer of this activity to the private sector in accordance with the provisons of Public Law 98-365, enacted by Congress last year.

We hope that the transfer will be accomplished, but the current terms of such a transfer leave Landsat in a difficult condition for several reasons.

First, a gap in the availability of new Landsat data seems inevitable and the situation grows more serious with each delay in consummating the transfer.

Second, under present terms, there promises to be little improvement in the quality of Landsat data during the period of private operation.

Finally, other nations, particularly France, are about to orbit systems that will provide data of superior quality in some respects and will make our competitive position difficult. Our Nation needs to decide if it wants to maintain a productive, competitive remote sensing capability for civil purposes and act on that decision.

If the transfer to the private sector is not accomplished, our capability degrades rapidly as a result of past decisions. There is no plan in the Government for continuation of the U.S. Land Remote Sensing Program beyond Landsat-5. A gap in the availability of data is not only probable, but almost certain.

Why has this situation come to pass and what can be done about it? Should we not be competitive in remote sensing? These are questions that we are studying and plan to address in our report. Nevertheless, I can say a few things about them now. The NASA R&D program in land remote sensing, without which there would be no Landsat, has been greatly decreased below what it was a number of years ago.

NOAA, struggling to maintain an operational system until it is transferred to the private sector, has little capability for improving the system and for developing the market that is so essential to future success.

We will be discussing these maters at much greater length in our report, including appropriate federal and private sector roles. I recognize that my testimony tells a tale of degradition of a national technological resource which should be aired for national discussion as we assess priorities in a period of budgetary stringency.

In conclusion, I would like to state the Board's views on NASA's microgravity program. I am happy to report that this program is moving forward well and toward several important experiments in the space shuttle. These experiments should indicate whether the field is ready for further expansion.

In the next few months, the Space Applications Board intends to increase its attention to this area by adding new members who are experienced in microgravity research and development.

Mr. Chairman, this concludes my statement.

[The following information was subsequently received for the record:]

NATIONAL RESEARCH COUNCIL,
COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS,
Washington, DC, April 15, 1985.

Hon. SLADE GORTON,
Chairman, Subcommittee on Science, Technology, and Space, Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, DC.

DEAR SENATOR GORTON: Your letter of April 3, 1985 requests us to answer some questions, for the record, in connection with the testimony of the Space Applications Board before your subcommittee on March 28, 1985. On behalf of the Board, I am pleased to submit the following answers to the questions appended to your letter.

The first question relates to the NASA ocean remote sensing project called TOPEX. This project was not approved in FY '86 but NASA has indicated its intention to propose TOPEX as a new start in FY '87. NASA intends to continue roparatory during the coming year, and hence, the delay in authorization will not result in a similar delay in the launch date. If the project had been authorized in FY '86, the scheduled launch date would have been October 1990; the FY '87 approval will slip the date to start February 1991, a loss of 4 to 5 months.

You asked about the effect of this delay upon French participation in TOPEX. Originally, the French were deeply concerned about the U.S. failure to start TOPEX in FY '86, but NASA informs us that agreement has been reached to proceed on the basis of an FY '87 authorization. If this date were missed, French participation could be endangered and the loss would be crucial, because their participation includes the launching of the satellite on the ARIANE rocket.

Your second question concerns efforts to commercialize Landsat. We realize this effort has been difficult, and is by no means certain, but as we stated in our original testimony, we still hope it will succeed. Whether or not Landsat is transferred to the private sector, our Board feels that NASA must not only continue but strengthen its R&D in support of land remote sensing.

You asked further about the impact of availability of data from the competing French project, SPOT. Since it is expected that Lansat 5 will be in operation at the time SPOT data becomes available, their entrance into the market as a competitor would have some effect on the sale of Landsat data. if there is no successor to Lansat 5 and if SPOT becomes the only provider of new data, American users would become dependent upon that source and it could take a domestic supplier several years to recapture the market.

Your third question concerns the feasibility of Landsat 4 retrieval and repair, which NASA has assessed as technically feasible but rather costly. We have no reason to question NASA's cost estimate, but we believe that, in view of the high cost, either NOAA, if they have the responsibility, or a private operator would elect to develop a new satellite rather than pay the cost of retrieval and repair of Landsat 4.

Your question No. 7, addressed to us, concerns NASA's choice to continue the Imaging Spectrometer instrument development (which might be useful in the 1990's), and to phase out the Multi-Linear Array (similar to current French and German developments). Our Board has discussed this choice with NASA on several occasions, and we understand the basis for NASA's decision, which is, that, in a period of budgetary stringency, they had to reduce funds in this area and chose to retain the instrument with longer term applicability. Our Board would not want NASA to cancel the Imaging Spectrometer, but we pointed out that cutting off the MLA has had a damaging effect as follows. The sole remaining private bid for operating the Landsat system has been made by the EOSAT company, a combination of RCA, Hughes, and others. Their original proposal included the use of an MLA in later versions of their new satellite. Their present proposal does not include an MLA and is based entirely on the Thematic Mapper (the prime instrument of Landsat 5). Their reasons for this change are twofold: (1) The reduction in government funding, and (2) NASA's decision to terminate the MLA development.

Your question #11 (addressed to us), refers to the relationship between NASA and NOAA in the weather satellite program. In our basic testimony, we pointed out that NASA had been responsible for developing the instruments and satellites now used by NOAA in its operational program, but that this interagency cooperation was vanishing, and it raised serious questions about the development of future instruments. The gap arises because NASA is concentrating primarily on science, while NOAA is not constituted to do the R&D that supports operations. We believe that a reordering of priorities in NASA, so as to provide greater support for operational earth-viewing programs, including weather satellites, is needed.

Sincerely,

MILTON W. ROSEN, *Executive Director.*

Senator **RIEGLE**. Thank you very much.

Mr. Shawhan.

Dr. **SHAWHAN**. Mr. Chairman and members of the subcommittee, thank you for inviting me to appear here this morning to discuss the work of the NASA advisory council's shuttle science working group. In the summer of 1983, NASA's advisory council established this working group with Dr. John Naugle of Fairchild Corp., and a council member, as chairman. I was appointed vice chairman at that time.

Also at that time, I was at my permanent post as professor of physics at the University of Iowa. Presently, I am on temporary assignment to NASA headquarters as Branch Chief of Space Plasma Physics. Dr. Naugle resigned from the working group late in our study to avoid any conflict of interest, since at that time we were exploring several commercial ventures including the Fairchild leasecraft.

At that time, I was appointed the acting chairman to complete the study.

This morning I come before you in that capacity to present our findings and to discuss some of our recommendations. The shuttle science working group consisted of 14 members. Half of these members were from universities and research laboratories, and half were NASA engineers from NASA centers, particularly Goddard Space Flight Center, Marshall Space Flight Center, Kennedy Space Center, and Johnson Space Center.

The working group visited each of these centers to tour the facilities, to discuss experiences with accommodating science and technology payloads on the shuttle, and to solicit ideas for increasing flight opportunities. Discussions were held with Headquarters program managers about issues related to budgets, to flights of get-away-special and of spacelab payloads and also about payload carrier concepts in development which offer capability intermediate to the get-away-special system and spacelab.

Examples of the intermediate carriers are the Hitchhiker attached carrier and the Spartan co-orbiting carrier. Headquarters discipline scientists were invited to indicate their needs and also our scientific colleagues were consulted to determine the types of investigations that should be considered for flight.

Based on these activities, the shuttle science working group came to the following conclusions:

The first, that flight frequency, flight costs, and flight accommodations do not currently meet the needs of the science and technology community.

Second, that the available payload carriers with the upcoming intermediate class carriers such as Hitchhiker and Spartan, should meet most needs and provide more flight opportunities. The science and technology community is not aware of the range of flight accommodations now becoming available; budgets available to develop payloads for increased flight opportunities are inadequate.

Then, finally, some development of new capabilities and some upgrades to the existing payload carrier systems can improve the flight opportunities and accommodations at lower costs.

Let me now expand on these conclusions and give some examples. The 1983 NASA/University Relations Study Group Report identified the need for frequent flight opportunities as paramount to the revitalization of NASA-university relations. Frequent flight opportunities at modest cost offer the possibility to train graduate students and young researchers in research techniques, to test new sensor systems, and to conduct investigations on problems with focused objectives.

In the 1960's and 1970's, frequent flights were possible with balloons, sounding rockets, and small scientific satellites such as the Explorers. For the 1980's, the shuttle was promised as a means to continue this tradition with enhanced capabilities. The spacelab system for shuttle was developed to accommodate science and technology payloads. With the flight of spacelab-1 in 1983 and with the pending flights of spacelab-2 and spacelab-3 this year, the shuttle is proving its capability to service complex and interactive investigations. However, the missions are not frequent, and cost over $100 million each for the payload.

The get-away-special system now is flying frequently for self-contained packages, but lacks the capabilities such as interactive controls, to serve many of the envisioned science and technology payload needs.

Two new payload carrier systems with capabilities intermediate to spacelab and the get-away-special are particularly promising. The Hitchhiker system is intended for three to six instruments with total capability of up to 500 kilograms in weight, 1 kilowatt in power, and kilobit-megabit per second data rates. A Goddard system has instruments mounted to a large plate which is mounted in turn to the side of the orbiter. A MSFC system mounts the plate to a special structure that spans across the bay. The first flight of the system is planned for fall of this year.

Two Spartan flights are planned for 1985, one flight to look at galactic x ray sources and the other to examine the solar corona. The Spartan carrier operates independently from the orbiter. It is deployed and retrieved with the remote manipulator system.

During the 40 hours of co-orbiting flight, it points to preplanned targets. Data are recorded on a tape recorder for post-mission analysis. This system achieves precise pointing, independent of the orbiter, and avoids the contamination envelope near to the orbiter.

With the get-away-special, Hitchhiker, Spartan, and spacelab, plus other carrier systems, a full range of accommodations are now possible. However, the shuttle science working group found that the potential user community was not generally aware of these capabilities. Proposals for Hitchhikers and Spartans have not been widely solicited.

The Hitchhiker carrier has been developed through the spacelab hardware budget, and Spartan through the sub-orbital program budget for fine-pointed rockets, with the addition of an augmentation in fiscal year 1985.

However, funds that could support the development of several Hitchhiker payloads and additional Spartan payloads are not apparent. In order to fly Hitchhiker as a payload of opportunity, it presently cannot command a timeline calling for pointing or any significant crew attention. The shuttle science working group felt that most science and technology investigations would require several orbits of pointing and some crew attention.

Other areas identified for upgrade or for new capability included modification to some spacelab hardware so that they could fly with other cargo elements such as satellites, and also the development of several pointing systems.

In addition, ground-based control centers need to provide more convenient interactions with the payloads. Perhaps remote centers can be located at investigators' institutions.

Based on these conclusions, many recommendations were put forward for NASA's consideration. Three of these we considered most critical.

No. 1, NASA needs to advertise the range of shuttle capability and to invite proposals for high quality and meaningful research from a broad segment of the science and technology community.

Second, NASA should establish a shuttle science and technology working group to represent the user's perspective and to act as a sounding board for issues on accommodations.

And, third, NASA should support intermediate class payloads. A level of $25 million per year can allow 20–30 opportunities for new payloads and for reflights using Spartan and Hitchhiker, for example. We suggest a level of about $7½ million in fiscal year 1986, $15 million in fiscal year 1987, $22.5 million in fiscal year 1988, and a budget of about $25 million, plus inflation, thereafter.

This approach provides a similar level-of-effort budget at about half the level of the current sub-orbital or explorer programs.

The shuttle science working group is convinced that the shuttle can be utilized more effectively for science and technology investigations. This utilization can fulfill one of the promises of the STS system and can lead to effective utilization of the space station complex in the near future.

Thank you, Mr. Chairman. This concludes my prepared statement, and I would be glad to answer additional questions.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question 1: Shuttle Users. Dr. Shawhan, according to your testimony, your Working Group found that potential Shuttle users are not generally aware of the range of Shuttle-related carrier systems available. Why have these users not been adequately informed about these opportunities? What is NASA now doing to announce these flight opportunities? Are NASA's current actions effective?

Answer 1: During 1975-1978 NASA did issue Announcements of Opportunity for the Orbiter Flight Test Series, for Spacelabs 1, 2, 3, 4 and for follow-on Spacelabs. The science and technology community did respond with hundreds of proposals for each AO solicitation. More recently Dear Colleague Letters have been issued for mid-deck locker and for Spartan flight opportunities but with a limited circulation. It has only recently became possible to consider a higher number of flight possibilities with the expansion of the Spartan program, the implementation of the Hitchhiker carriers and the increased flexibility for use of the Spacelab hardware. Therefore, the user community had not been generally informed of these new possibilities since they were not ready for large volume usage. The Shuttle Science Working Group (SSWG), felt, however, that inputs from the user community would have been desirable to define the system requirements and to develop enthusiasm from the potential users. Now, NASA has published several brochures that describe the features of the Spacelab, Hitchhiker, Spartan and Get-Away Special systems. These brochures are being provided on request to the community. The SSWG hopes that NASA will actively try to reach potential users through presentations at professional meetings and at advertised workshops and that NASA will solicit proposals. In this manner the broader science and technology community can be reached; the reaction should be many high quality proposals. Before undertaking a broad solicitation of proposals, NASA needs to establish a budget level, to implement a management scheme and to develop the manifesting procedures and flight rate.

Question 2: Intermediate Payloads. Dr. Shawhan, your Working Group has recommended that NASA provide additional support for immediate class payloads, beginning with $7.5 million in FY 1986 and growing to $25 million in FY 1989. Do you assume that this program can be funded primarily through a one-to-one reduction in the Suborbital or Sounding Rocket programs?

Answer 2: The SSWG was particularly concerned that a level of effort budget eventually reaching the $25M per year level be identified. The establishment of a separate budget line was recommended since this action would provide visibility for a new capability and would help protect the funds for the intermediate payload use. Some of the funds could come from reprogramming from the Sub-orbital program--this approach was taken to develop the Spartan carrier and the initial payloads. However, a Spartan flight is approximately 3-5 times more expensive than a pointed rocket flight so that additional funds are needed to keep a reasonable flight frequency. (Spartan was augmented in the FY 85 budget). Note that sounding rockets flights for atmospheric and some space plasma physics investigations that make in situ measurements at altitudes below the Shuttle cannot be replaced by using the Shuttle. Another existing budget line that could be considered for reprogramming would be the Spacelab Payloads. Some of the investigations planned for Spacelab could be accommodated as intermediate payloads. NASA must make an assessment of the balance between flight opportunities via the Sub-orbital, Explorer, Spacelab Payloads and Intermediate Payloads programs. More funds may be required to meet the community requests and to take advantage of the Shuttle capacity.

Question 3: Budget Implementation. In the budget climate, adding "new" money to the budget request is extremely difficult. Can you recommend a strategy to accommodate your recommendation of $7.5 million for FY 1986 that does not require "new" money and is contained within the Space Science and Applications budget?

Answer 3: Some of the re-programming possibilities are mentioned in the answer to Question 2.--reprogramming from the Sub-Orbital and Spacelab Payloads programs plus some "new" money. NASA has been taking steps to implement an intermediate class payload program. The Astrophysics Division of the Office of Space Science and Applications (OSSA) has developed Spartan and will fly the first payload this summer. The Spacelab Division of the Office of Space Flight (OSF) recognized the need for "payloads of opportunity" and has developed the Hitchhiker carrier systems. Also they provide other pallet systems and Spacelab hardware configurations that meet a wide range of attached payload needs. The appropriate NASA officials should be consulted to verify the budget numbers, however, the SSWG understands that funds from several differrent sources may be planned for intermediate class payloads that approach the proposed $7.5M level:

(1)	OSSA Sub-orbital for Spartan	2.0
(2)	OSSA Augmentation for Spartan	2.0
(3)	OSSA Spacelab Payload Set-Aside	3.0
(4)	OSF Integration of Payloads on Hitchhiker	1.0
		$8.0M

Items (1) and (2) are ongoing; Item (3) is a new wedge that has to be created and Item (4) is planned only for the first two Hitchhikers of each type--it does not continue.

Question 4: Broader Scope of Research. Dr. Shawhan, according to your report, NASA can increase flight opportunities and broaden the scope of Shuttle-related science and technology research by making modest modifications and enhancements of existing hardware, including both intermediate class carrier systems and Spacelab. To what extent is NASA making these hardware changes? How much would these changes cost? Why were these changes not part of the original hardware design?

Answer 4: A number of the recommended modifications and enhancements are being implemented (although not necessarily because of the SSWG report). For example, the ASTRO mission will use a Spacelab hardware configuration that co-exists with deployable satellites; a pointing system with moderate weight capability is being developed for the SHEAL mission; and the Spartans beyond Spartan-3 are being upgraded to provide better pointing accuracy. All of the suggested modifications and enhancement could probably be implemented for about $25M. In practice these items are being implemented in an evolutionary manner within the level-of-effort budgets. Originally, it was thought that Spacelab would fly four times per year in dedicated flights. Now the Spacelab missions are found to be expensive and the STS is not scheduled for 40 flights per year so other approaches are necessary. Also, many of the needs identified now are based on experience from the first science and technology flights. With further experience and constrained funds it makes sense to evolve to a better accommodation. Note that the SSWG has proposed an oversight committee to help guide this evolutionary process.

Question 5: Spacelab Cost. Dr. Shawhan, according to your study, NASA can reduce Spacelab mission costs and shorten the interval between Spacelab missions by implementing the recommendations of Spacelab Mission Implementation Cost Assessment (SMICA) study. How and to what extend is NASA implementing these recommendations. Will the upcoming Spacelab mission reflect any of these changes?

Answer 5: Spacelab-3 and Spacelab-2 are the next two Spacelab missions to be flown this year. Each of these missions was developed before the SMICA study was conducted. In fact the SMICA study is really based on the Spacelab 1, 2, 3, and 4 development experiences. SMICA did identify schemes to reduce the volume of documentation, to develop more common documents and to consolidate the ground and flight safety reviews. All current Spacelab, as well as Hitchhiker and other missions are benefiting from the implementation of these recommendations. The SSWG felt also that the cost of Spacelab missions would decrease as the result of increased experience with the documentation, the hardware and the user community. Upcoming mission such as ASTRO, SHEAL, and SUNLAB may reflect the experience factor. The first full Spacelab to implement all of the SMICA recommendations may be Space Plasma Lab in 1990.

Question 6: Shuttle Science and Technology Working Group. Dr. Shawhan, your Working Group has recommended the establishment of a Shuttle Science and Technology Working Group to represent the users' perspectives and to act as a sounding board for issues on Shuttle accommodations. Could you share with us the composition of this Working Group, as you envision it, relative to the representation of international participants, state and federal government agencies, universities, and scientific disciplines? How responsive has NASA been to this idea? What problems will persist or surface without the establishment of this working Group?

Answer 6: The SSWG emphasized the need for an oversight committee since the Spacelab hardware was managed in the Office of Spaceflight (OSF) and the payloads managed by the Office of Space Science and Applications (OSSA) and other Offices, since new carrier systems were being developed and existing systems modified and since there now existed experienced users of the STS. The SSWG concept for the Shuttle Science and Technology Working Group (SSTWG) was to establish a committee that reported directly to the Associated Administrators of OSF and OSSA and periodically give status reports and raised issues with the NASA Advisory Council. Requests for opinions from the SSTWG would come from all user divisions within NASA and from the user community. Suggestions would be given to the implementation divisions in OSF and OSSA. We envision a committee composed of 6-8 outside scientists from universities and government labs with STS experience and 5-6 NASA key engineers primarily from the responsible NASA centers--MSFC, GSFC, KSC, JSC and LaRC. NASA Headquarters personnel would be expected to attend the 2-3 meeting per year as appropriate. It was felt that the scientists could be chosen to represent the range of disciplines. International participants would be welcome but were not specifically appointed. It was felt that the U.S. representatives would voice common concerns and the meeting logistics would be easier. It might be that a similar committee should be established for commercial users and that these two committees (plus others?) should meet together once per year to discuss common topics. Without such oversight committees, the available funds and STS capacity may be less effectively used. For example, the SSWG agreed that the Hitchhiker "payload-of-opportunity" concept is very desirable but that the Shuttle accommodations do not include any significant crew attention or any dedicated attitude timeline. However, most all of the potential science and technology investigations examined need some prescribed attitude for several orbits. The SSTWG would certainly address such an issue.

Question 7: Application to Space Station. Dr. Shawhan, to what extent are your findings and recommendations applicable to science and technology operations aboard the space station? Will the space station require an entirely different method of accommodating science and technology experiments than on the Shuttle?

Answer 7: The SSWG had extensive discussions concerning the relationship between Shuttle and Space Station accommodations. From a solicitation, selection, development, and technical accommodation standpoint, the Shuttle and Space Station are very similar. Note that the OSSA data base for the Initial Operating Configuration (IOC) time period of 1992-1994 includes both Hitchhiker and Spartan elements as well as possibilities for other module and attached payloads. One area identified for extensive enhancement is the payload operations capability. For investigations on orbit from 3 months to 2 years it becomes a requirement to allow the investigators to operate their payloads and to asimilate the data at their home institutions. Therefore, a capability for "telepresence" needs to be developed. Schemes for establishing "telepresence" can be explored with the intermediate class payloads on the Shuttle, for example. Also it is important to use the Shuttle experience to decide the trade-off between manned crew interaction and remote ground operations and between manned assistance and robotic activities. A large experienced community using the Shuttle provides a large enthusiastic community which can effectively use the Space Station.

Question 8: Spacelab Re-evaluation. Dr. Shawhan, according to your report, there are about 20 Spacelab investigations that were selected in 1978 that are presently not being developed. Yet, I understand that NASA is re-evaluating these investigations. What is the status of this re-evaluation?

Answer 8: The NASA Office of Space Science and Applications (OSSA) has just completed the re-evaluation of the Spacelab investigations selected under AO-78-2. Dr. Jeffrey Rosendhal the Assistant Associate Administrator of OSSA should be consulted on the exact procedures and details. Of the approximately 20 investigations that were not being developed, about 7 were dropped completely (due to technical or scientific consideration) and the others were assigned to missions which would be completed by 1992. These decisions conform to the OSSA baseline Spacelab Payloads budget. This new flight model may also include a small wedge for the support of intermediate class payloads (see answer to Question 3, Item 3).

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS

Question 1: The Shuttle Science Working Group Report was issued in September 1984 and was submitted to the NASA Advisory Council in October 1984.

Has the Working Group received a formal response from NASA? What has been the reaction within the Office of Space Science and Applications and the Office of Space Flight to the Working Group's recommendations?

Answer 1: The Shuttle Science Working Group (SSWG) presented the report to the NASA Advisory Council who transmitted it to Mr. Beggs. Subsequently the SSWG has been terminated. To my knowledge, NASA has not yet provided a formal response to the NASA Advisory Council. Informal discussions have been held with both the Office of Space Science and Applications (OSSA) and the Office of Space Flight (OSF) concerning many recommendations in the SSWG report. Most of the recommendations were well received, however, implementation of some recommendations involve policy decisions and of others require prioritization with respect to the realities of the budget. Both OSSA and OSF acknowledge that the Oversight Committee may be a good idea. OSSA is working to set aside a wedge for intermediate class payloads from the Shuttle Payloads budget. In addition, the first Spartan is scheduled to fly this Spring and the first Hitchhiker by the end of the year. ASTRO will be the first payload, using Spacelab hardware, that is adapted to fly in a mixed cargo mode. A pointing system for heavy payloads is being developed for the Shuttle High Energy Astrophysics Laboratory (SHEAL).

Question 2: A basic theme of your report is that NASA must utilize the unique capabilities of the Shuttle to provide frequent, low cost flight opportunities.

(a) However, doesn't the use of the Shuttle raise concerns among the Science community because of pressure problems, contamination problems and poor pointing capabilities?

Are these concerns that the Hitchhiker and Spartan will remedy?

(b) In your effort to develop more frequent flight opportunities, especially for graduate students, what guarantees are there that enhanced use of the Shuttle won't cause a further reduction in the level of support for balloons and sub-orbital rockets?

At present, what percent of the sounding rockets experiments require the capabilities of Spartan — longer flight duration, fine pointing, power, etc.?

Answer 2a: Some types of science investigations are sensitive to pressure increases, contamination and poor pointing -- particularly the atmospheric, astrophysical, solar and planetary telescopes. These investigations can be conducted with Spartan or with selected orientations of the Orbiter to avoid the ram effects. Pointing from the Orbiter can be significantly improved with the Instrument Pointing System (IPS), for example. Other investigations such as high energy physics or research on structures are not sensitive to the local Orbiter environment. Still other investigations such as space plasma physics are interested in the Orbiter-plasma, and neutral gas-plasma interactions that occur. Some of these investigations can be conducted using the Hitchhiker carrier system.

Answer 2b: Some reduction in the requests for balloon and sounding rocket investigations is anticipated as the Shuttle capabilities are developed and demonstrated. For example, Spartan has been developed with sounding rocket man-power and funds to provide a capability that far exceeds that of fine-pointed rockets (40 hours vs. 5 minutes of data). Simularly, some in-situ atmospheric, ionospheric and auroral zone measurement can be more effectively obtained from an orbiting attached Hitchhiker or a detached Spartan. However, in-situ measurements in the lower and middle atmosphere will always require balloon and sounding rocket investigations. Approximately half of the 20/year solar and astrophysics sounding rocket investigations can make use of Spartan. This usage is about 25% of all sounding rockets. Plans are also being formulated for some atmospheric and space plasma physics investigations to use Spartan and a new concept called Spartan Probes which eventually could also be 25% of the current sounding rocket program.

Question 3: In order to provide more frequent flight opportunities, it would appear that "payloads of opportunity" present one possible solution (these are experiments that are ready to go on a moments notice and can fill any nook or cranny on the Shuttle). However, the Working Group felt that most science and technology investigations would require several orbits of pointing and some crew attention, thus diminishing the value of "payloads of opportunity."

Would you please comment on whether or not "payloads of opportunity" are a viable option? Don't they provide a base from which dedicated missions, Spartan or Hitchhiker flight, could evolve?

Answer 3: Both the Get-Away-Specials and the Hitchhiker are "payloads of opportunity" - the Spartan is manifested. The payloads of opportunity can provide many flight opportunities for science and technology experiments that do not require a pointing timeline or significant crew attention. However, the Working Group did not identify many contemplated investigations that met these constraints. However, if some minimal pointing opportunities — such as 12 hours divided into four 3 hour (2 orbit) intervals — could be baselined for Hitchhiker, then many types of investigations could benefit. The short intervals should not violate thermal constraints. Additional pointing could be negotiated on a case-by-case basis. Spartan, once deployed, is independent of the Orbiter crew and pointing — it accomplishes a pre-programmed pointing routine.

Question 4: Based on your testimony, it would appear that the Shuttle has phenomenal capabilities, but it is somewhat deficient when it comes to accommodating science and technology payloads. One might say that it doesn"t sound like a "user friendly" system.

(a) Could you please give the Committee an idea of what type of pointing systems and ground base control centers are required to enhance use of the Shuttle?

(b) Aren't there similar requirements for potential science/technology users of the space station? Wouldn't the enhaned use of the Shuttle for science and technology investigations establish a basis of support and expertise for effective utilization of the space station? Are any similar arguments being made to NASA by the Task Force on the Scientific Uses of the Space Station?

Answer 4a: Some examples of pointing systems are as follows: (1) Develop Spartan to the 10 arc sec capability to match the current fine pointed sounding rockets; (2) develop a heavy payload pointer for large 1000kg-3000kg payloads with a 0.1 degree precision to accommodate cosmic ray telescopes, for example; and (3) develop a 3-axis 10 arc sec pointer for 100kg-500kg (single instrument) payloads for atmospheric and planetary telescopes. Many investigators using the Hitchhiker, for example, would crowd the Johnson Space Center or Marshall Space Flight Center Payload Operations Control Center. These investigations in fact need a rather low rate command and data display capability. Investigation teams are probably best located at their home institutions with command and data transfer at 9600 band plus two way voice links. In some cases video might also be required. The present Johnson Space Center "Remote POCC" interface provides most of these services but it has not been extensively utilized by science and technology groups.

Answer 4b: The SSWG felt strongly that all of the recommended Shuttle accommodations and user experience would certainly immediately provide benefits to the Space Station utilization. These benefits include the first hand experience of a large science and technology group including young researchers; the benefits and limitations of the Station could be readily established. This same conclusion has been stressed by the Bank's Task Force who also propose to make use of the Shuttle in conjunction with the Space Station to provide tests of instrumentation and to carry out coordinated experiments.

Question 5: As you are probably well aware, this Committee has long supported an Extended Duration Orbiter (EDO) becasuse it would greatly expand our in-space capabilities for a very reasonable investment.

(a) Would you please give the Committee the Working Group's position on the need for an EDO that could extend the Shuttle's in-space staying time beyond the 10-day limit?

What advantages does an EDO present for science and technology investigations?

(b) Doesn't the Bank's Commission also indicate the need for an EDO?

Answer 5a: The Shuttle Science Working Group discussed the Extended Duration Orbiter (EDO) at length. It was determined that two situations could take good advantage of extended Shuttle missions: (1) those investigations that require time to collect photons such as telescopic surveys of the faint sky objects and time to evolve physical or chemical processes such as growth of crystals or evolution of biological systems and (2) those investigations which require the interplay of many types of instrumentation under a range of conditions such as the active electron beam and plasma wave experiments of Space Plasma Lab. For now investigations have been designed for completion in 5-7 days. For certain objectives such as crystal growth, the longer time is essential and not satisfied by multiple flights. An EDO of 14-20 days provides 2-3 times more experiment time which allows a new regime of experimentation. Apparently, it may be possible to add a fifth energy kit to another orbiter which would allow up to 10 days (per Spacelab-1) at a cost of about $10M. However, for about $35M, it may be possible to provide a cyro wafer for installation in the rear of the payload bay yielding a mission time double that possible now. This capability would serve all Shuttle users now and in fact may be required to meet the stay-on-orbit requirements to build and to service the Space Station elements.

Answer 5b: The Bank's Task Force has made many of the same points stated above. The EDO is a natural and desirable evolutionary step for the crew and for science.

Question 6: The Working Group recommended the establishment of a Shuttle Science Oversight Committee, a group that would meet twice a year to guide the program and to maintain contact between the user community and the Shuttle operators.

Based on your experiences with the Shuttle, should such an Oversight Committee be limited to Shuttle science or should it address the concerns of all Shuttle users? Should it approach the non-NASA community as well as the NASA community?

Wouldn't such an activity — facilitating use of the Shuttle — be a logical task for the new Office of Commercial Programs?

Answer 6: The Shuttle Science Working Group felt that an Oversight Committee specifically for the NASA science and technology community was justified since their requirements seem to require new or upgraded capability that were not necessarily required by the commercial community, their source of funds were from NASA (Code E primarily) and their interfaces were directly with NASA Centers rather than with contractors. It is recognized that the Commercial and DOD research communities do have similar concerns with respect to accommodations that could be represented. However, the new Office of

Commercial Programs may desire to establish their own Oversight Committee to address JEA's, commercial rates, proprietary data, payload specialists, etc. in addition to accommodations issues. (Perhaps the two committees could meet once a year to discuss common issues).

Question 7: The Shuttle Science Working Group recommends creation of a separate budget to support intermediate class payloads. This budget would be $7.5 million in FY 1986, increasing to $25 million in FY 1987.

(a) What would be the principal uses of this budget -- development of instruments as well as flight costs, or just the flight opportunity?

(b) What would be the desired lead time from inception of mission, to development of instrument, to actual flight of experiment?

(c) Does the funding of such an office require "new" money, or could monies be reprogrammed from the Spacelab or Suborbital Programs accounts?

Answer 7a: The proposed budget was based on a model for 50% new payload development, and 50% reflight of developed payloads including the integration, mission analysis and data analysis costs. With Spartan and Hitchhiker, 20-30 flight opportunities per year seem possible.

Answer 7b: From discussions with colleagues and discipline chiefs, it seemed possible to develop most new instruments in 2 years. Once developed, the instrument could fly in six months after assignment to a Hitchhiker, for example. Reflights might occur at intervals of 1 year. Since Spartan is manifested, the interval between instrument completion and flight might be closer to a year.

Answer 7c: The Shuttle Science Working Group felt that a new budget line for intermediate class payloads was desirable for visibility and for protection of the funds. However, the most important issue was to identify some budget wedge--whether a new or old line or whether new money or reprogrammed is really a NASA management issue. As indicated in Answer 2b, some funds have been reprogrammed from the Sub-Orbital Program for Spartan.

Senator RIEGLE. Thank you very much.

Dr. Fisk, concerning your testimony regarding training our next generation of scientists, I am wondering how high a national priority this should be. Can an increase of $11 million for university laboratory equipment and $4 million for graduate research programs in fiscal 1986 really make much of a dent in this program?

And I am wondering, in your view, what type and scale of investment should we really be talking about and over what period of time if we really want to put ourselves in a position tc move as rapidly as we can and as we need to in these areas.

Dr. FISK. I think it is a fair statement to say that $11 million in science equipment and $4 million for graduate students is just the beginning of the solution. I think you have to look at this in terms of a long-range problem, in the sense that technology evolves on scales of 3 years or so in many of these areas, and so you have to be looking to replace major portions of your laboratory equipment in universities on that scale.

Now, the $11 million number which was generated in the NSA/university study was a number that looked feasible to obtain. Perhaps more than a solution to the problem, I think it is a fair statement to say that the real number is a lot bigger than that.

Senator RIEGLE. What order of magnitude, if we were to really step up to the requirement, are we talking how much?

Dr. FISK. I would imagine a number more like $50 million a year for NASA.

Senator RIEGLE. $50 million a year.

Dr. FISK. Yes.

Senator RIEGLE. Let me ask you, Mr. Rosen, during the last budget cycle, Congress had a hard fight to ensure the development and flight of the advanced communications technology satellite. Your technical advice and recommendations aided that effort.

I would like your opinion as to whether the Federal Government is making the same mistake in remote sensing as it made in communications. Are we leaving the door open for foreign preemption of a dynamic market here?

Mr. ROSEN. Senator, I think the opinion of our board would be that it is. And we regret to see the decline of activity of this sort in NASA and in NOAA.

Now, let me make it clear that NASA continues to support the science that is the basis of remote sensing. Where the great gap exists is in the application of that science to practical uses, which NASA used to do and did very effectively and, by doing it, created the field of land remote sensing.

I do not know what it will take to reverse this, but if we do not fill this gap—and you hear about this all the time, of the United States being preeminent in science but lagging in the application of science—other nations using our science will compete with us.

This is what we think has to be done. We think both NASA and NOAA have to rejuvenate the whole program that aids the application of remote sensing science to practical uses.

Senator RIEGLE. I have a great concern about that. The President's Commission on competitiveness, as you probably know, dwelled on this issue and the fact that we are not getting the applied side of our scientific work to the extent we should be, and we are falling behind in a lot of areas.

It helps to explain in part the trade deficit rocketing up to $150 billion this year.

I am going to have other questions for you for the record. I must leave shortly for another meeting that I have to attend. So I will be offering those questions to you, and I am sure Senator Gorton has other questions as well.

Senator Rockefeller, do you have questions at this time?

Senator **ROCKEFELLER**. No, Mr. Chairman.

Senator **RIEGLE**. Let me just inquire if I may of Senator Gorton's staff, would it be his desire that witnesses stay for a period until he returns, or should we excuse the witnesses and submit Senator Gorton's questions to them for the record?

[Pause.]

Senator **RIEGLE**. Oh, I beg your pardon. Senator Rockefeller was blocking my view of Senator Gore. Either that, or my eyesight is just fading.

Senator **GORE**. No problem. I have no further questions.

Senator **RIEGLE**. Thank you, Senator Gore. I think what we will do then is, we will adjourn the hearing at this point. Senator Gorton will have questions for the record. He may or may not be able to come back on a timely basis, and rather than have you all just sitting here, I think we will conclude the hearing at this point and ask that you respond to those questions in writing.

Thank you very much for your testimony today.

[Whereupon, at 11:26 a.m., the hearing was adjourned.]

NASA AUTHORIZATION FOR FISCAL YEAR 1986

WEDNESDAY, APRIL 3, 1985

U.S. Senate,
Committee on Commerce, Science, and Transportation,
Subcommittee on Science, Technology, and Space,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:37 a.m., in room SR-253, Dirksen Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator Gorton. Welcome to this hearing of the Subcommittee on Science, Technology, and Space as we examine the administration's proposal to develop a permanent manned space station.

Just as he did in the State of the Union Address in 1984, the President emphasized in his 1985 address the importance of establishing a permanent presence in space through the development of a manned space station.

This cosmic stepping stone has captured the spirit and imagination of people all across the Nation, and has provided our space program with a vision and direction that will carry us into the 21st century and to the doorstep of opportunities never dreamed of.

A year ago the subcommittee strongly endorsed NASA's request to establish the institutional framework for the Space Station Program and to mobilize its energies for a strong beginning. During this past year negotiations with our potential international partners have progressed to the point that initial memoranda of understanding are about to be signed.

In addition, it is expected that in a matter of days the first major contractual efforts for the program, both domestic and international, will begin. From these efforts we will obtain the conceptual foundation for what could prove to be the most dramatic endeavor to date in our quest to explore and exploit space.

The fiscal year 1986 space station budget request of $230 million is $50 million less than NASA requested, and according to the NASA Administrator, Jim Beggs, in his testimony before the subcommittee this reduction in funding will delay the completion of the program by approximately 1 year.

Today we hope to ascertain if the proposed reduction will affect in any way the scope of the program and will impose any unnecessary risks on that program.

Certainly the international participation in this program adds an exciting yet complex dimension to the design, development, and operation of the proposed facility. There are sensitivities related to issues such as technology transfer and nondiscriminatory access which must be addressed on a continuing basis. These are not easy problems to resolve, and, as with any cooperative endeavor, will require give and take by all parties.

The extent to which the ultimate facility is user friendly and provides an environment in which meaningful and productive research can be conducted is of paramount importance to the success of the undertaking. The subcommittee is pleased that NASA has stepped up to this requirement. Select committees have been created by NASA to provide input and insight into the discussion of space station utilization and the potential benefits that may ensue from this opportunity. We will hear from two of these committees today.

The subcommittee recognizes that the space station will not satisfy all of the needs and desires of all potential users. Nevertheless, we encourage NASA to maximize the utility of the space station within available resources in a manner that will distribute the benefits to as many elements of our society as is possible.

As we examine these and other relevant issues, we are fortunate to have with us today several distinguished guests who will comment on the Space Station Program and on NASA's progress to date in accepting this challenge.

Our first witness will be NASA's Associate Administrator for the Space Station, Phil Culbertson. Before Mr. Culbertson begins, Senator Rockefeller, do you have any opening statement?

Senator ROCKEFELLER. I do not, Mr. Chairman.

Senator GORTON. Senator Riegle, do you have any opening statement?

OPENING STATEMENT BY SENATOR RIEGLE

Senator RIEGLE. Thank you, Mr. Chairman. I do.

Mr. Chairman, today is the fourth of five hearings scheduled by the subcommittee to review the fiscal year 1986 NASA budget request of $7.886 billion. Today's hearing will focus on NASA's fiscal year 1986 budget request of $230 million for the Space Station Program as well as provide a forum in which the subcommittee can review NASA's progress to date in the Space Station Program.

I am most pleased to have Mr. Culbertson and Mr. Pryke with us today because together they represent one of the most important facets of this proposal—the desire for international cooperation. I applaud NASA and ESA for the progress that has been made to date to negotiate an international space station agreement and for their efforts to develop a space station for the benefit of all mankind.

I also look forward to the testimony of Dr. Banks, who has gained quite a reputation as the defender of the space science community in the Space Station Program, and of Mr. Cohen, whose report should greatly effect the technological advances and spinoffs associated with the development of a space station.

Mr. Chairman, as the members of this subcommittee know, I have long been supportive of NASA research and development activities. Quite frankly, NASA technology has served as a bank of knowledge available for application to new products and processes of benefit to the national economy, industrial efficiency, and human welfare. NASA technology has been transferred to the fields of medicine, public safety, transportation, industrial processes, pollution control, energy systems, construction, law enforcement, home appliances, farm machinery, sports and recreation, food products, and many other areas. NASA technology has been a valuable contribution to American employment, productivity, and lifestyles.

In reviewing the NASA request for the space station and in determining whether or not I will strongly endorse the space station, I intend to apply the following standards:

Will the space station result in technological advancements and spinoffs that benefit mankind?

Will the space station help the U.S. maintain its competitive edge and technological leadership in space activities?

Will the space station result in economic gains and improve the balance of trade deficit?

Will the space station create, apply and protect American technology?

Will the space station result in innovation that spurs new industries and revives mature ones? and

Will the space station act as a catalyst for additional cooperative space ventures.

Mr. Chairman, I realize that at this point in time there are many questions and policies concerning the potential development of a permanently manned space station that need to be addressed. I also realize that NASA has yet to sign the memoranda of understanding with our friends and allies—ESA, Canada, and Japan—concerning the conditions of the phase B design definition studies that are to commence on April 15. I am pleased to note that the United States has agreement on text with all of our partners. In light of this situation, I realize that there probably will not be answers for all of the subcommittee's questions. However, I do hope that there will be enough answers to fully justify the Space Station Program's fiscal year 1986 budget increase and to maintain the support of this committee for the development of a permanently manned space station.

Senator GORTON. Senator Hollings, do you have a statement?

OPENING STATEMENT BY SENATOR HOLLINGS

Senator HOLLINGS. Mr. Chairman, on January 25, 1984, the President in his State of the Union Message told the American public that:

> We can follow our dreams to distant stars, living and working in space for peaceful, economic and scientific gain.

The President then directed NASA "to develop a permanently manned space station and do it within a decade."

Although that statement was made just over a year ago, today we have assembled a panel of witnesses ready to discuss the first phase of that permanently manned and internationally supported space station which will begin on April 15 of this year.

Mr. Chairman, the development of a permanently manned space station is a bold undertaking. When one realizes that it has been less than 25 years since man first orbited the planet and only 15 years since man landed on the Moon, the advent of a space station is a testimony to the burgeoning technology of our times and the Nation's determination to put that technology to use. It also is a testimony to the desire of men of all nations to live together in peace and to jointly pursue common endeavors for the benefit of all mankind.

Quite frankly, if there is any concern about the initiation of such a bold endeavor at this point in time, it's the effect of this proposal on the Federal budget and the Federal deficit. As the Members of this subcommittee realize, there is incredible pressure upon the Congress to find an equitable solution to the budget crisis. Therefore, I would suggest that our witnesses make their best effort to justify space station expenditures and provide the subcommittee with irrefutable arguments as to the benefits of a space station.

Mr. Chairman, I look forward to today's testimony. I might note that I am particularly interested in the testimony of Mr. Pryke, Dr. Banks, and Mr. Cohen. The efforts of their particular organizations to increase international cooperation, make the space station user friendly, and promote advances in and incorporation of robotics and automation in the space station are most admirable.

I also should indicate that the committee appreciates the efforts of Mr. Culbertson and NASA to keep it advised of developments in the Space Station Program. I hope this dialog will continue.

I want to thank Mr. Drew, Mr. Simpson, and Mr. Oleson for being with us today to express the opinions of their organizations, and I look forward to their testimony.

Senator GORTON. Mr. Culbertson, it is all yours.

STATEMENT OF PHILIP E. CULBERTSON, ASSOCIATE ADMINISTRATOR FOR SPACE STATION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY JOHN SHEAHAN

Mr. CULBERTSON. Good morning, Mr. Chairman. It is a real pleasure to be back before the subcommittee to talk about our status and our immediate future on what I consider to be a marvelously exciting and productive program, one that in my view will change the nature of the space program dramatically when we get into orbit and it becomes operational both in that it is a national program and it is an international program.

You spoke of the participation that we have on an international basis, and it does indeed add complexity to the management of the program, but I believe it has the opportunity to provide additional capability which far offsets the complexity of the management.

Let me go back to where we were just a year ago when we appeared before you and asked for your support and requested $150 million for the fiscal year in which we are now working. We have focused much of our time and effort since we talked to you before toward the upcoming studies, program definition studies, and the advanced technology which will provide us the basis for making program decisions in about a year which will provide the basis for the development of the program.

Immediately after we left the hearings last spring, we made center assignments to five of our NASA centers. Goddard, just outside the beltway here in Washington, Lewis Center in Cleveland, Marshall Space Flight Center in Huntsville, Johnson Space Flight Center at Houston, TX, and, of course, the Kennedy Space Center.

We also established a three-level management structure with direction coming from Washington, management of the program both technically and financially at the Johnson Space Center, what we call level B, and in the five centers I just mentioned, being those who will have the management of the contract activity and will in the final analysis manage the development of the system elements.

We moved the center of gravity from Washington, where it had been in the task force, down to the Johnson Space Center at level B. They reexamined the configuration and the concept which had been developed in Washington, and revised the configuration somewhat for purposes of contractor studies.

And on September 15 issued a request for proposal [RFD] to industry for a study, a 18- to 21-month study leading to a sound definition of the configuration which we would propose to proceed in development with, one which was based on enough analysis and technical development activity to provide us a good understanding of its probable cost and its probable capability, and of the schedule on which we would complete it.

Those proposals were then received back by NASA on the 15th of November. There were 15 responses to our request for proposal. Four of those were considered nonresponsive to the request, and we have evaluated the remaining eleven. We reported to the administrator on the results of that evaluation on the 13th of March.

There were six contractors selected to do the effort. They are assigned to Marshall, Lewis, and Goddard, and it was concluded that three proposals that had been received for the job to be done at Johnson were—there was not a basis that that time, in that stage of the evaluation, for adequate discrimination among those, so we have negotiated with the three remaining contractors, and the results of that negotiation will be reported for consideration by the administrator, who is the source selection official.

The definition effort is planned to be initiated about the middle of this month, tentatively focused on the 15th as the probable start date. We will be joined in definition studies by comparable studies under the management of ESA, Japan, and Canada. They will run until essentially January 1987. We will spend the first 9 months of those studies studying a fairly broad range of configuration concepts with the anticipation then that we will select at the end of those 9 months a specific configuration to do the preliminary design on.

You see the model here in front of you, which is not as elegant-looking as space stations were perceived to be 20 years ago, and I will not spend the time going into exactly why this configuration is as it is today. We can do that another time. It is a large configuration. You see it with the shuttle in scale.

Pressurized modules to which the shuttle is attached form the living and working interior working quarters of the space station. The power system is illustrated as a photovoltaic system, although we have not yet frozen on a photovoltaic system. It has in this configuration about three-quarters of an acre of solar cells representing more power than the United States has put into space in the history of the space program.

The overall configuration is a little over 100 meters in its longer dimension, and the rest of it you can sort of follow. It has a lot of advantages, which we will show you.

Senator **Gorton**. In fact, the scale is shown by the presence of the shuttle?

Mr. **Culbertson**. Yes, it is all on scale. All of the elements of the space station either fold up or in another way get into the cargo bay of the shuttle one at a time. As it stands there, it represents about nine shuttle flights' worth of system.

Those flights taking place at the time that they start putting things into orbit and then assembling it in orbit, so it will take that kind of a logistic flight over a period of something like a year, and our schedule for that is in the 1992-93 timeframe.

The fiscal 1986 request is primarily based on the continuation of those studies and on the advanced technology effort which supports the decisionmaking process which is yet ahead of us.

Specifically, we are asking for $82 million for advanced development in things like the alternative solar power systems that we are considering, closure of some of the life support systems so that we can considerably reduce the logistic system in future years, closure of part of the water system and the atmospheric system, the technology of stabilizing, stabilizing and controlling a very large spacecraft like this, which is considerably more flexible and has therefore much lower natural frequencies than the spacecraft that we have been flying up until this time.

The budget then calls for $74 million to continue the particular design studies that will be going on. This is an extremely important part of the program.

We do not want to enter into a development program without a very sound understanding of the configuration of the interfaces, the relationships of the United States' elements to those of Japan, Canada, and the European Space Agency, and an assurance that the technology will be available at the time it is called for.

Those two parts of the program together represent about 70 percent of the budget request. We will continue in fiscal year 1986 the utilization studies program, and you will hear a little bit more about that from Peter Banks. We will be working on the automation and robotics part of the program which we were asked by Congress to undertake. You will be hearing from Aaron Cohen and John Erickson on that this morning.

We are delighted with the progress and the work that has been done on automation and robotics, and feel that it will enhance the space station and our consideration of the space station in a very effective way. We are also very much aware of Congress' desire to have us look at a man-tended approach to becoming fully manned.

That has been well written into the request for proposal. The contractors have responded in an effective way, and we are satisfied that we will have a good basis for understanding the cost and effectiveness of that option at the time that the configuration decision is made about a year from now.

We have worked closely with the European Space Agency, Japan, and Canada, which are the three international entities which have expressed an interest in becoming partners in this program. We have completed the memoranda of understanding [MOU] which will govern our interaction during the program definition phase. We have agreed upon text of the MOU with each of those three organizations, and we expect to get those signed promptly.

The space station represents, I believe, a significantly enhanced capability from that which this country and the world have had. It represents a permanent laboratory in space where we can carry out laboratory kinds of sciences which are inaccessible to us today.

The life sciences, other activities, and microgravity phenomenon are of particular interest to the private sector for potential commercial exploitation.

It will serve as a permanent observatory with certain instruments attached exterior to the base of the spacecraft which will be operational on a permanent basis. It has in addition to this manned part of the system two or more automated platforms, and the program in location is yet to be determined. The particular configuration, though, is not yet frozen, because we continue to analyze the requirements which will be placed upon those platforms, but it is a manned and unmanned kind of a program.

It is important to recognize that we do have a desire to provide a capability which is consistent with the needs, whether they be manned or unmanned, of the user community.

It is a servicing facility on orbit to which we can bring the global telescope and other large free-flying spacecraft for the kinds of attention that man can give: changeout of instruments, repair, maintenance, adding expendables.

It is an assembly facility for us to begin to understand how to assemble large structures for deployment in low Earth orbit, geosynchronous orbit or beyond, a capability which is extremely limited with today's capabilities.

It will provide a basis for a manufacturing facility which is available to—manufacturing facilities available for commercial exploitation, an area which most of us have dealt with the 15 contractors today who are spending their own money exploring the possibility of commercial production in space feel it is one of the most promising parts of the space program, although today yet relatively well undefined.

It is a transportation node where we can assemble spacecraft at propulsion stages that go beyond the limits of low Earth orbit. And finally, it provides a basis for virtually all of the future endeavors in space that we have imagined or we have conceived of going into the next century.

It remains to be seen, I think, now that the President's Commission on Space has been formed, the degree to which the space station is in fact such a stepping stone. Those of us who have worked the problem for the last 2 or 3 years feel that it clearly is a first step, whether we want to do something more creative in geosynchronous orbit or the Moon or beyond.

That is a longer summary than I had hoped to give you this morning. I am sorry I have taken so much time, but it is a brief synopsis. We have a movie which was created at the Johnson Space Center showing a possible assembly sequence of this configuration.

It is a computer sequence and design. It lasts about 12 minutes. I would be delighted to have it shown now or later.

Senator GORTON. Let us show it right now.

Mr. CULBERTSON. I will try to narrate it. I have not narrated it in detail, but I will try to fill in. It shows individual steps taken in the sequence of 8 or 10 shuttle flights. It shows some of the robotic and automated capabilities it will have.

We have not yet developed the sequence in detail, because we have not yet developed the configuration in detail, but it illustrates the principles by which we expect the assembly sequence to take place.

[A film was shown.]

Mr. CULBERTSON. Let me say it is a working film.

The first flight will carry the basic structures and the ability to control the power and to control the first elements. Here you see the remote manipulator in the shuttle cargo bay beginning to take out and beginning to remove the structure with the present shuttle remote manipulator taking things out of the cargo bay and beginning the construction or erection sequence.

This method of building trusses which can be unfolded in this direction is reasonably well developed by a fair number of contractors, and this is a surprisingly accurate representation of the way the trusses can be deployed, recognizing that in zero gravity you are considering only the mass and not the weight of the system.

That is the first step in the power system or energy system, and at that point it will be able to stabilize and power itself. It is obviously not yet manned. Now we are beginning the deployment of the major longitudinal members. Those are generally spring-loaded kind of deployment techniques which will essentially self-deploy. Others are operated by cables. When they deploy, they lock in place and have the rigidity that is necessary.

We have now got a boom or a crane on the structure itself in addition to the one that we had in the shuttle cargo bay. That is part of the shuttle.

Those are the radiator systems that were deployed. This configuration has an advantage in that it is what we call gradient stabilized, that is, gravity forces will keep the—I hesitate to say bottom end, but the end on which the modules are attached pointed continuously at the center of the Earth as it rotates about the Earth.

This then is the first habitable module. There are obviously a number of possible arrangements of the interconnection between the modules. This is one which has some interesting features in that it allows for access to all elements of the pressurized system from either of two directions, which is an attractive feature from the standpoint of safety.

As I recall, it was with the completion of this step that we concluded that it could be manned for the first time. Another attractive feature of this configuration is that it provides access to the space station from the shuttle at a great distance from the large solar arrays. We approach the space station with shuttle in a fairly open direction, and it simplifies the proximity operations in the docking.

Our present plan and thinking is that within the so-called IOC configuration we would have two laboratories, two habitats, and then a logistic vehicle which has carried the supplies to and will take supplies or unused refuse from the space station and bring it back to Earth.

I think this movie also illustrates the extent to which the disciplines of robotics and automated systems already are well embedded in our thinking about how a space station will not only be operated, but how it in fact will be assembled. That would be the orientation relative to the Earth in which it would fly.

With that particular orientation and this kind of stabilization, it is fairly easy to add additional elements as the system evolves in years ahead without basic changes in the stabilization control system. I would like to say it is going to be that easy and that quick. It is obviously not going to. But at least it gives you the concept of how we are thinking.

I would like to close these remarks now, and I am ready for questions on your part or however you intend to proceed with the rest of the witnesses today.

Thank you, Mr. Chairman.

Senator GORTON. One question about the model. I take it that the framework passageways that are open here are in fact open. There is no communication from one part to another without being fully suited.

Mr. CULBERTSON. Well, the manned access is that which is contained in the modules themselves or defined by the modules themselves, and the tubes between them and the shuttle. That is the pressurized part of it. Yes the open trusswork is in fact open trusswork,

Senator GORTON. What is that square unit there?

Mr. CULBERTSON. The square box? The square box is conceived as a storage area or hangar, if you will, which probably will not be incorporated into the IOC configuration but was put there by our thinking because it affects the mass of the system, which we will consider later on.

One thing that may show up near that location then, down in the pressurized area, is that with a configuration this long, there is a slight constant gravity force down at the pressurized modules themselves, because actually zero gravity occurs at the center of gravity, which is up near the center, and if there is anything that is sensitive to that about ten to the minus sixth G's, which will be a constant gravity force in the pressurized modules, we would have to locate it up in that area.

Senator GORTON. Mr. Culbertson, last month the Senate Budget Committee voted to freeze at the fiscal year 1985 appropriations level for the budget function which includes NASA. I would like your detailed comments on how such a freeze affects the scope and schedule of the Space Station Program, including the definition stage, which of course you are engaged in right now.

Mr. CULBERTSON. It depends on the level at which the freeze takes place. If Mr. Beggs in answer to that question says it is frozen at the agency level, he would elect not to cut the space station budget or the request from $230 million because we are now scheduled in a way which allows us in the next 9 months to do those things which are necessary to understand the configuration and the general state of technology that we would then continue into the preliminary design, with which we would go into the preliminary design.

The date of next January is important to us because the information that we have at that date will form the basis of our defense of our explanation to Congress next spring. For the way that the fiscal 1987 budget would be spent, and it is in that year that we plan to initiate the development of the system.

If the $230 million is significantly reduced, we will have to either rescope or reschedule the definition effort and the technology which supports the definition effort. We would not choose to rescope it. We think that the detail with which this job should be done is properly defined, and that we should go that far before we plan to initiate the development.

Errors made or inadequate effort in the definition phase can be disastrous to budgets and schedules once development has begun. We want to get a deep understanding of it.

Senator GORTON. So you are going to do the best you can to retain this $230 million if there is a freeze of some sort or another, and then I understand you will require roughly $850 million for fiscal year 1987?

Mr. CULBERTSON. That is our present expectation.

Senator GORTON. I am sorry, $500.

Mr. CULBERTSON. $580 million for definition. Now, if it is frozen at the space station level and I live with $150 million, we will have to restructure the definition effort considerably and extend it considerably and probably delay the initiation of development by close to a year.

Senator GORTON. When will the memorandum of understanding with the international participants be signed, and when will they begin their phase B work?

Mr. CULBERTSON. We expect to sign it within the next 45 days, and they will begin their work within the next 45 days. As far as we can tell, all three participants——

Senator GORTON. Promptly upon signing the memorandum?

Mr. CULBERTSON. Promptly on signing the memorandum of understanding. There are some steps that must be taken internally both in ESA and Japan, but they are advanced well in those steps.

Senator GORTON. Further on that subject, how long do you expect the international participants to continue to participate in the space station program once their elements are in place? On the other hand, what chance do you think there is that the European Space Agency will develop its own space station?

Mr. CULBERTSON. I think the European Space Agency definitely plans to have an autonomous space station capability sometime after the beginning of the next century. They have made that very clear.

They have talked about the elements they think are necessary for that independent capability. The portions of the cooperative program with which they will participate are systems which they would anticipate later incorporated into their independent capability.

My own belief is that we will not find them withdrawing any of the elements which they have added to the space station as a private cooperative program, but they will duplicate it for their own.

Senator GORTON. What about Japan and Canada? Will they be likely to stay with us?

Mr. CULBERTSON. To the best of my knowledge, Canada has no independent plans.

Senator GORTON. I mean, as opposed to joining up with ESA.

Mr. CULBERTSON. Oh, I think that they could well join with ESA, but I expect Canada to remain totally committed to this program through its lifetime. They might at the same time participate with ESA in its independent capability.

The Japanese have not indicated a specific plan for having an independent capability, but it is pretty apparent that they are thinking in that direction, too. I believe they are somewhat behind ESA in their planning. They would have to have a tremendous development program to get an independent capability, and I would be very surprised if they withdrew from this program for reasons of a desire to become independent. Now, they might for other reasons withdraw, but not for those reasons.

Senator GORTON. Have you begun to work on a pricing policy for the space station?

Mr. CULBERTSON. We have begun to think about a pricing policy, but we have not yet got a pricing policy. The Europeans are very anxious, and all of them are anxious, to know what our estimates of operations costs will be. And we have indicated that later on this summer we hope to come up with a more informed basis for estimating operations costs.

Senator GORTON. More informed than the $500 million Mr. Beggs testified to?

Mr. CULBERTSON. More informed than that, yes.

Senator GORTON. The Banks Committee, Mr. Culbertson, from whom we will hear after you have completed your testimony, has told us that to this point NASA has avoided incorporated into its space station infrastructure multiple, smaller, co-orbiting platforms, opting instead, of course, for the single larger satellite.

Could you comment on this subject and support your choice for the type of co-orbiting platform you prefer at the present time?

Mr. CULBERTSON. Well, we do not have a preferred co-orbiting platform right now, and I am trying to avoid making a determination of what either the co-orbiting or polar platform ought to be, because it seems to me we must make sure that the interests of the user community and the specific requirements of the using community are well coalesced to provide the kind of direction we want.

So, we will study both co-orbiting and polar platforms, but that decision, I believe, should await approximately another year until we can properly relate the capabilities that we think we can put into them with the desires that people have.

One of the participating elements that ESA is going to study is also a platform, so we have that to consider, their primary interest being a polar platform or Sun synchronous platform, so that the picture on platforms, the only part of the platform picture that is clear is that we have committed to and intend to remain committed to the development of at least two platforms in the Space Station Program, and for a variety of reasons I think that is an excellent thing to do.

The thing that we cannot do, though, is support everybody's requirement for some kind of a spacecraft bus or basic system within the Space Station Program. Our resources will not allow that. We want to undertake the development of at least two. We want to have a design which can be picked up by other people needing this kind of a capability with other budgets.

Senator GORTON. Will a four orbital shuttle fleet be adequate to meet the needs of the space station as well as the other functions of the space shuttle?

Mr. CULBERTSON. Yes. I think it will require a little bit of juggling during the 1 year, about a year when we expect to get the seven or so flights to assemble the space station, but beyond that, we believe that the orbiter fleet with its 24-flight per year rate is adequate to support the program.

Senator GORTON. Should the French develop a Hermes shuttle, would it play a significant role in providing transportation to and from the space station?

Mr. CULBERTSON. I do not see a significant role for it, but I am certainly not ruling out that possibility. We know something about what Hermes is. I was in Paris last week, and talked to the French Cnes about the Hermes program.

It is not envisioned by them as being available in that same time frame or within the first few years anyway of shuttle operation.

We have told the Europeans that the Ariane V or any of the Ariane configurations and the Hermes certainly might be used at least by them in support of the space station, their space station interests, but we have not found a unique requirement for either one of those two, either Ariane or Hermes, which could not be satisfied equally well by the shuttle. So they are not part of the program itself, although they may well be made so that they are compatible with the program and be complementary.

Senator GORTON. Last year you were asked by the Appropriations Committee to study as part of the phase B activities a mantended facility that would evolve into a manned space station. To what extent have you examined that question over the last year, and have you reached any conclusions?

Mr. CULBERTSON. We have not done much further study ourselves on that. The thing that we have done that we were directed to do is to incorporate that part of the study into the definition studies that we had.

It was incorporated in the RFP in a number of ways. Having gone over the responses to our requests for proposal from each one of the contractors, it is clear to me that they understand the intent of the study of the man-tended configuration.

The plan is, and this has been developed in conjunction with the other committee, the plan is that we will get the results of the contractors' studies incorporated into reports which we will submit to Congress about coincident with the time that the basic decision is made by NASA on the configuration which will be the subject of the preliminary design.

That means that in about a little less than a year, we will submit that report with the contractor's analysis and then our recommendations based upon those contractors' studies.

Senator GORTON. Last week Bert Edelson said that the highest priority mission for the space station would be servicing and repairing the space telescope, and the second priority would be the deployment of one or more polar orbiting platforms.

Can you tell me whether or not this set of priorities is a NASA position, and if so, how it was established?

Mr. CULBERTSON. It is the priority of the science part of NASA. It is the science priority. Now, I am saying this—I must say that we have a variety of users or customers, and the strongest and most clearly expressed one within NASA is the science requirement.

There is an engineering and technology community which desires to use the space station to understand how to build large structures and understand how to stabilize large spacecraft like this, and so there is a collection of users from the technologists.

That is separate from the responsibilities and the interests of Dr. Edelson, and we are asking them to prioritize their requirements for the use of the system.

Senator GORTON. How will you set those priorities from these different disciplines?

Mr. CULBERTSON. We have a board which has been set up which I chair which has representation from all the different using communities to express their priorities for the capabilities in the system, and this board will take the final action on determining what portion of those capabilities which are desired can in fact be built into the space station.

Senator GORTON. What time frame is involved in coming up with those decisions?

Mr. CULBERTSON. There will be a series of decisions. We will have a decision within the next 3 weeks on what capabilities we expect the contractors to consider as kind of the bottom line as they go into their definition studies.

As the studies get nearer and nearer completion and it is apparent what real capabilities we have to provide the systems for the $8 billion that we have talked about, that is, a year from now there will be another determination of what is the baseline capability that we will provide, and that will provide the first formal step of deciding that that is the space station which we will build.

That board, however, will meet periodically throughout the life of the development program to review where we are and to evaluate either compromises that we have had to make in order to satisfy all the requirements or perhaps the possibility of increasing the capabilities in certain areas, but it will be a continuous board which will last for the next 5 or 6 years beyond the point changes are possible.

Senator GORTON. Has the Department of Defense defined more clearly than it had a year ago how and to what extent it may wish to use the space station, and if so, do you have any idea of the extent to which it may ask to use it for strategic defense initiative experimentation?

Mr. CULBERTSON. Their position has not changed in the past year. They have repeated the position that they have no requirements to be placed upon the space station and do not expect to use it. On the other hand, I anticipate that either with the SDI research requirements or some other aspect of defense use of space there will be research requirements or research activities they would like to have carried out in the space station. There has been no formal or informal statement to that effect, although we remain in close coordination with the Department of Defense by my briefings to them and by their representation at JSC and others.

Senator GORTON. So the Department of Defense hasn't expressed any concern about international participation in the space station?

Mr. CULBERTSON. No, that is correct. They have not.

Senator GORTON. Do any of your international partners have any concern about DOD use of the space station?

Mr. CULBERTSON. Yes, we have been asked questions by all of our international partners, and I have said and Mr. Beggs has said essentially what I just told you, that there is no requirement.

We would be surprised if sooner or later they did not desire to do some research. This, after all provides a research capability more than anything else, and we have told them that, and they are satisfied with it as long as the requirements are consistent with provisions of the United Nations (Treaty) on (Peaceful) Uses of (Outer) Space.

Senator GORTON. Does that mean you are not concerned with and your definitional studies do not involve the protection from hostile attack of the space station?

Mr. CULBERTSON. No, I will not say that I am not concerned about it. It does not involve at the moment any formal consideration of hostile attack. This is not a configuration which is easy to hide. It is not a configuration which is easy to maneuver.

It is not a configuration which is easy to defend. It is a civil research laboratory in space. And there is very little that could be done to correct any of those situations.

Senator GORTON. How many personnel are there likely to be at Johnson Space Center for the overall systems engineering and integration? And will it all be NASA personnel or will you look for a contractor to provide some of these services?

Mr. CULBERTSON. Well, while John Sheahan on my right is looking at the specific numbers that we have, we are today going into the program with basically an in-house capability to do the systems engineering.

We will have support contractor assistance in some of the areas where there are contractors who have particular expertise, but it has been a matter of anticipation that we do not plan to have a systems engineering contractor for the total program.

Our current estimate is, there will be on the order of 600 people, civil servants at Johnson assigned to the program at level B and level C, and I do not have a number here which splits that between what we call level B and level C. I can supply that for the record if you would like.

Senator GORTON. Please do.

[The information referred to follows.]

Of the 620 civil servants planned at the Johnson Space Center in FY 1986 for the overall systems engineering and intergration, 195 are allocated to Level B and 425 are allocated to Level C.

Mr. CULBERTSON. But let me add that this is the largest program on which NASA has undertaken to do the systems engineering itself, and I have considered it prudent to carry an insurance policy in my hip pocket, and we are not going to let the thing get out of control if it becomes necessary.

Senator **Gorton**. Thank you.

Senator **Riegle**. As we are finding almost daily when we have hearings, we have other committees on which we serve meeting at precisely the same time. This morning the Banking Committee's Securities Subcommittee, of which I am a member, is having an important hearing on corporate takeovers that started at precisely the same time as this meeting, and so again we are going to have to be moving back and forth between these meeting sites.

I want to question you about automation and robotics in the space station—that is of particular interest to me—with the thought in mind that what we are able to learn in an advanced scientific way or the space station is able to find its way back into commercial applications here on Earth. I am very much interested in those kinds of linkages. So, my questions will be along that line.

Pursuant to the congressional mandate, NASA has just submitted to the Congress a technical memorandum entitled "Advancing Automation and Robotics Technology for the Space Station and for the U.S. Economy."

At the same time, Congress has just been supplied copies of the California Space Institute Automation and Robotics Panel report entitled "Automation and Robotics for the National Space Program," and additional reports compiled by five aerospace contractors on a variety of subjects related to the development of a space station.

I am wondering if you could tell us how these recommendations will influence the shape of phase B studies and how they will be incorporated into the phase B implementation plan.

Mr. **Culbertson**. Let me comment on it briefly, and then suggest that perhaps if Aaron Cohen when he testifies could go into it in greater detail, because he chaired the ATAC [Advanced Technology Advisory Committee], which prepared the final report, but I can comment on it briefly.

This activity, of course, is a direct result of the request by Congress a year ago to undertake such a study and to prepare it in a way that could be used by the contractors in phase B. There are three kinds, three levels of automation and robotics which we in the Space Station Program, with which we are concerned.

There is the first level, which is the level at which those areas of automation or robotics clearly have to be done had there been no special mandate that we do the study, they must be done because it is necessary to do those things to make a space station and make it effective.

Realizing that we are talking about a crew of six or eight running 24 hours a day, 365 days a year, there is very little—we do not want to have man doing those things which machines can do better, because there is really very little man-hour time to devote to those things which a machine cannot do, and we do not want to waste his time doing things that can be done otherwise.

The space station inherently will be a highly automated system going as far as we are able to go with the present state of the art in artificial intelligence, but it would certainly incorporate a high level of expert systems, things that monitor its own status, that make it tolerant to failures.

The film that I showed earlier showed the degree to which robotics is going to play just in putting the thing together. There is that level, and the contractors would routinely incorporate their considerations of that level.

There is a second level of automation and robotics which was specified and called out in the reports that you referred to. Those are the things that could enhance the capabilities of the space station if it appears to be a cost effective kind of a thing, and I would guess that there would be many additional things that we would incoprporate in the space station, not that they are mandatory to do, but because by incorporating them we can make it a much more effective and efficient space station.

We can reduce its operating costs, and the contractors will be directed to advise us to do the cost effectiveness studies, the kind of analyses which tell us those things which clearly we ought to do just because we want to make an effective space station out of it.

There is a third class which then is more related to the kind of thing that you did. What can we do in the way of advancing the technologies and incorporating the space station, but where the primary reason of enhancing the technologies in the United States for other uses other than just the space station, but using the space station as a focus for the advancement of technology.

And that is the principal thing that the ATAC report was directed to. We will ask the contractors to study those, both the second and the third areas of automation and robotics, to study the real applicability of those to the space station, and develop for us the soundest estimate they can about the cost of that development and incorporation and the benefit of incorporation.

We will not ask them to incorporate those things without our specific concurrence, because I consider those aspects which are primarily focused toward advancing the state of the art, to be outside of what I refer to as the $8 billion space station.

Those are those things that we were asked to identify last year by the Senate, and we will identify them and discuss further then the degree to which NASA should be asked to carry out the mandate of funding for the research and the development of that part of the robotics and automation technology. So, we will be back to talk to you after the contractors have done their work in showing what the real applicability and cost of incorporating them into the space station would be.

Senator RIEGLE. I think with the continuing pressures on the budget which you are finding both with OMB and the Congress as well, that every opportunity that can be found to help advance commercial applications on Earth is money in the bank for the Space Program in the future.

I know there are a lot of things that are interesting to do and are worth doing in terms of the kind of space station activities that have been discussed in part this morning. I think one should make sure that we do not slide over the automation and robotics opportunities because there is keen interest in it, and I think in the end building more in rather than less in will be helpful all the way around.

I think there are big gains, dollar-and-cents gains here and, I think, program support gains which are important, I think, for you to think about. I know, of course, that you do.

What is the current level of funding the Office of the Space Station is assuming for automation and robotics activities in the space station?

Mr. CULBERTSON. Well, I have not examined that particular question and cut the program in that direction. If I may, I would like to answer that for the record. We can, I think, do it, but I do not have an answer to give you.

[The following information was subsequently received for the record:]

The Space Station's Advanced Development Program incorporates a significant amount of automation and robotics activities within the various technological disciplines, but the program was not structured to discretely identify automation and robotics. The Centers will be examining their portion of the Advanced Development Program to identify and quantify those activities relating to automation and robotics as part of their formulation of the fiscal year 1986 Operating Plan.

Senator RIEGLE. If my information is correct, the Senate Appropriations Committee has assumed 10 percent or a minimum of $800 million. Does that ring a bell?

Mr. CULBERTSON. I guess I understand that number. But that number is, as I understand the direction that we were given, that number of the potential $800 million is a proposed expenditure in this third category of automation and robotics that I was talking about. It is the expenditure which we would undertake to manage for the advance of the technologies and the incorporation of that advance into the space station.

The number that I do not have at hand is what we would expect to spend in automation and robotics under any circumstances without that mandate.

Senator RIEGLE. So it seems to me then that would fall in a sense as to whether that would be an add-on beyond the basic cost of the effort or incorporated within it. The intent is that that be incorporated within it, and we would not be asking in that designation of the three different areas that you spoke about, we would not later on be seeing requests for additional money to do those things, but part of the money we see going in for the project as a whole would be dedicated in that direction.

Is that right? Or are we thinking differently on that?

Mr. CULBERTSON. Well, at the moment, I am afraid we are thinking differently. You see, when we undertook the program, we knew that there would be a significant robotic effort that went into it. That was included in our original estimate of the so-called $8 billion that we have recently talked about. We did not within that $8 billion assume that there would be a specific effort directed toward the advancement of robotics and automation technology.

I certainly have no objection to saying that as part of the overall space station responsibility and program, but I cannot say that that was included when we gave our original estimate of the $8 billion.

Senator RIEGLE. So then if the Congress had a strong feeling about wanting to dedicate some portion to sort of advance that forefront, it would be something then that we would have to work out and have an understanding on, so that whether everybody was happy in the end or not, at least we had some mutual understanding of what we were going to be doing here and how much money was going to be spent.

Mr. CULBERTSON. I would like to engage in that conversation.

Senator RIEGLE. I am sure you will be part of it, but your answer tells me that we have not resolved that yet, that that is something that is still ahead of us to work out, it seems.

Mr. CULBERTSON. Well, I thought we had, but I think my answer says we have not, yes.

Senator RIEGLE. What is your opinion of the Cal space recommendations concerning advanced technology development and particularly their recommendations that a long-range technology advancement and demonstration program of significant size, apparently in the range of $190 million a year, be funded to ensure automation and robotics technologies are developed both for the IOC and beyond, and that an external review or advisory panel be constituted to conduct in-depth reviews of NASA's automation and robotics activities?

Mr. CULBERTSON. I am not the person that can answer whether the $180 million a year or what level of basic research is necessary. I am very pleased with the report.

I am satisfied that as we went through this thing we got the right people to study it and give us the advice. You may recall that we asked Dr. Frosch, former NASA Administrator, now vice president for research at General Motors, to oversee the whole process, and he was an enthusiastic supporter of the program.

I think it is also highly desirable for an overseeing group to be organized representing those people who are deeply immersed in the so-called state of the art representing the people who would use that technology terrestrially for commerce representing the aerospace industry to make sure that we were doing it the right way in the shuttle.

I intend to set up such a committee, and I think it will have a very important function.

Senator RIEGLE. Let me move into one other area, and then I will have some questions that I will have you respond to for the record.

In a recent House hearing you testified that the $8 billion estimate was neither a floor nor a ceiling. You also testified that after the phase B definition period of 21 months you would be better able to identify the available options and costs.

Does this mean that the space station cannot really be bought by the yard, so to speak, and that the $8 billion estimate is not a very precise one? Is it sort of what we use as a yardstick? Or are there always options available within the $8 billion cost?

In other words, should we think in terms of the fact that that figure may have to grow for a time? Or should we figure that one way or another we will design ourselves into that kind of a total budget figure?

Mr. CULBERTSON. I think that I owe it to the Congress as we come to the conclusion of this definition of effort to tell you what I believe at that time can be achieved with $8 billion.

Now, when we talked 1 year ago to the President, and I have talked to you in the past, we have said that it was our estimate that with $8 billion we could have two laboratories and two habitats, a set of logistic vehicles, and about 75 kilowatts of power, and that we could house six to eight people.

That was the best estimate we could make with fairly limited study. We had not asked contractors to assist us, but it was necessary for us to define something. That was our best estimate of what it was that could be done with $8 billion.

I will not be reluctant to come and tell you 2 years from now that that is either less or more, as we have described the system. It is either less or more than we can provide with $8 billion.

That is the purpose of a definition effort. I am going to spend perhaps $500 million trying to get that answer, but $500 million will get us a lot more than that answer. It will get us a long way into the design. But that is the whole purpose of a program definition.

And I believe that I owe it to you to tell you what we believe at the time with the assistance of the contractors can be the space station for $8 billion. I think you should expect from me also a recommendation at that time as to whether or not that is in my version or in NASA's view the space station which we ought to proceed with.

It may be that history would say it is unlikely. We may come back and say it would cost less. Maybe we will say that is the right one. Maybe it was 10 percent higher. But I think I owe it to you to do that.

Now, also, when we talked about the $8 billion space station before we did not take into consideration what international participation there might be. As we view it now there will probably be over $3 billion effort going into international participation, and that will add capability to the system.

We have got to come out with a balanced capability, our own, what we provide, what the international partners provide. And it is that balanced capability that I think I need to talk to you about; and then what share the United States would bear.

I think that I owe it to you. When I give you that answer, I ought to be able to commit to you that I believe that that is what the program will cost, and is the time, I think, we ought to sign on the dotted line, so to speak.

Senator Riegle. Just one other thing. To try to step out of the technical role that you are necessarily in, if I brought into the room four or five of my constituents who were in town visiting today, as they are increasingly this time of the year from all over the country, and I asked you to say to them why we ought to spend this $8 billion now on this future schedule for the space station—it is a lot of money. What would you say?

We have got all kinds of budget problems and competing alternatives and so forth. And if I asked you to indicate to them in lay terms why the $8 billion is worth spending for this or what this is going to produce, and I asked you to put it into some context that would help them think about how this makes sense maybe over the period of the next 25 or 50 years in terms of what you would foresee from your very special vantage point, I would like to hear what you would say to them, because I too want to have that reply at hand when I am asked that question and I would like to be able to respond using some of the insight that you have that I do not have.

So what would you say to them that would help them see the wisdom of doing this and convince them to want to reach into their pocket and sort of pull out the tax money to build the space station, and how they could visualize what this is going to return to them and to the country and their kids in the future?

Mr. CULBERTSON. I would take two steps. I would say first that I think it is inevitable that the United States will remain in space in one way or another, whether it is for the development of commercial products, work that can come out of things that could be done in an environment in which gravity is not a factor, whether that it is the development of new products or the reduction in the cost of old products, or whether it is the scientific understanding we can get about processes, so that that understanding can be brought to terrestrial application in metallurgy in other systems which require fluid transport, which is so highly affected by gravity that today we cannot really understand the rest of the process.

But whether it is for that purpose alone or whether that is combined with the fact that there are observations that can be made from space of the entire terrestrial sphere for weather or communications, or whether it is purely for looking outward and understanding more about what the universe is about, or finally, whether it is because a symbol of technological capability of the United States which is to stay abreast of this field and not fall behind the rest of the nations who are also moving more and more aggressively into space.

For those four reasons I am convinced that America will remain in space. If we do remain in space, and to the degree we do remain in space, it seems inevitable to me that we must have the capability to remain in space rather than deliver small pieces to space and then abandon them completely. That is, we need a facility in space which is a permanent kind of a facility in which men can live and work and do the kinds of things that we do in laboratories here on earth.

We must let automatic systems, unmanned systems, small systems do those things which can be preprogrammed and those things which are terrestrially done by automated systems; but there are many things, many occasions that we have to do things which cannot be preprogrammed, and that requires the presence of man.

We also need to create a laboratory environment where man can, as somebody said, we need space and time to tinker. And there is a certain amount of tinkering that goes on in any kind of fundamental research.

What we are proposing to build with this $8 billion is such a place which is permanent so that we do not just drive up in our recreational vehicle and spend a weekend and then come back when we need to have men in space. But it is a permanent location where we can store things, where we can assemble things, where we can have a continuity of program that is not broken by intermittent flights.

We have looked at what kind of facility it might be. We believe this is a very first step. It is a fairly limited scale kind of thing. It is not a big laboratory. It will house six to eight people. We are trying to provide the power which is appropriate, drawing from the best information we can get from all the prospective users of such a capability, provide them with the kind of laboratories that are necessary to do the things that I spoke of. Fundamental research to provide an observation point for those things can be done too.

The Russians are doing this. The Europeans plan to do it. The Japanese are seriously thinking about it. We think that by combining the Western World into a single configuration we can, at a minimum cost to the United States, develop a limited but certainly effective capability, not only to do the things that we will want to do in the 1990's, but to develop the systems and the understanding which will allow us to go beyond that.

Now, I do not like to use this too often, but we are doing this for something less than a cup of coffee for each of your constituents every day. It is not an expensive program on an individual basis.

What will it mean to them in the future? I am convinced it will mean new drugs and other new kinds of materials that will be of great value to the United States.

I think I am not going to promise breakthroughs, but there are lots of people who are looking at the way that this can enhance the quality of life from a medical standpoint. I think it will give them a sense of pride in what the United States is able to do. I think it will provide closer ties for this Nation, between this Nation and some of our allies on a very highly visible, high techology civil program. So I think it is important for this country.

I think it will lead in directions which will allow much better weather forecasting. It can lead in directions which will improve our ability to sense the progress of diseases, crop diseases. I think it will increase our ability to understand how to use the resources that the Earth has.

I do not have a lot more that I can add to that.

Senator RIEGLE. Well, you said a lot, and I appreciate the fullness of the answer. As I say, I will have additional questions for the record, Mr. Chairman.

Senator GORTON. Senator Rockefeller.

Senator ROCKEFELLER. Thank you, Mr. Chairman.

Basically just two questions. I may have some more to submit.

The authorization last year for NASA goes to this concept of only for peaceful purposes, and the chairman touched on the subject to some degree. But I find since I am on the subcommittee, I am looking at magazines I did not use to look at, and in the Aerospace America 1984 September edition, Jim Beggs talks about his belief that the Department of Defense is at some point a potential user.

Now, it does not say whether it is for research apart from military applications or whatever. But he says that the Department already uses NASA's wind tunnels and flies payloads obviously aboard the space shuttle. And then one reads in High Technology that the Department of Defense is at least reluctant to be drawn into the space station; that is, the entire program.

In fact, the article sort of implies that they are against it, because I guess the implication is that if it takes a number of space shuttles to get all the materials up there to build a space station, and then I think I saw that every 90 days the crew has to be either relieved or certain logistics changes made. So the space shuttle is going up and back on a fairly regular basis to the platform. And therefore, that would in some way impinge upon the Department of Defense capacity to use the space shuttle for whatever purposes.

I am not really hung up on this, and it may be that there is no violation, for example, of the so-called peaceful purposes provision of last year's NASA authorization if DOD is doing certain kinds of basic research which are in fact as important to them as pharmaceuticals would be, let us say, for the commercial sector, or ceramics of particularly high intensity or whatever.

Could you speak a little bit about DOD's proposed uses of the space station? In other words, with SDI in the wind, so to speak, there is competition for dollars and, that the Department of Defense would be reluctant about this project is interesting.

If it is just on the basis of competition for the space shuttle, well, that is one thing; but if it has some other meaning that they want to be able to get into it in some other way—now, you answered that to some degree.

You said they had indicated no interest at this point, but here is Beggs saying it seems inevitable to him, and DOD is saying well, we do not like it, because maybe it precludes our use of some form of this, and I am not sure.

I would like to have some sense in an era of concern about the militarization of outer space about what would be a proper role for DOD in terms of participation for certain kinds of applied research or whatever which would be in the national interest but not necessarily of a threatening nature.

Mr. CULBERTSON. Well, first let me say that within the United Nations there are certain agreements on what is meant by the peaceful use of space, and that does not mean and clearly does not mean within the United Nations that military agencies will not use space for communications or for research and a variety of other things, and so do not make synonymous the nonpeaceful use of space with the Department of Defense. They are not the same thing.

So we have said—and I did not mean to imply earlier that we have not said that the peaceful use, the peaceful military use of space is beyond consideration for taking advantage of the presence of the Space Station. What I did say was that today they have not expressed any requirements.

Now, I personally keep the Department of Defense as well informed as I can about what direction we are going. I go over and brief Dr. Cooper, and Jim Abramhason and I talk about the space station, so they know what we are doing. There is a lieutenant colonel assigned to my office for 2 years in liaison. We have a couple of Air Force officers at Johnson at the level B center, and I think the Navy will soon send an officer down to remain aware of what is going on.

I believe that the space station is an appropriate mechanism for the Department of Defense to carry on fundamental research in space activities, advanced development in some kinds of areas, much of which would be unclassified, as a matter of fact, many of their uses of the space shuttle would be unclassified.

I have said before, and Mr. Beggs has also made the statement, this is not a logical operational vehicle for the Department of Defense. It is not in an orbit which is necessarily particularly interesting to them. It is a big, awkward, clumsy kind of a machine up in space from the standpoint of a military kind of a machine.

It is fine for my purposes. It is a good machine for support of fundamental or even applied kind of research, and I expect that to take place. But I come back to the position before that they have not expressed either any requirements to be put into the system or any consideration for being allowed to use it.

My belief is well—and furthermore, they did not support our initiation of the program. They voted against it when the time came for a vote. I can only speculate on why they voted against it. They voted against it because they did not have a need for it, and they considered it to be competition in the economic environment. I am essentially certain that it will be used by them for research consistent with the provisions of the United Nations.

Senator ROCKEFELLER. All right. Within NASA itself, the budget for fiscal 1986 does not, I believe, have any new research initiatives; that is, new over the previous year.

Mr. CULBERTSON. The orbital maneuvering vehicle is what we call a new start. That is a development program. That is in conjunction with the space shuttle. There are no new science initiatives.

Senator ROCKEFELLER. All right. Should that be of any concern? By that I mean is the largeness of this very dramatic, excellent, expensive space station initiative at a time of the so-called budget freeze or scarcity era, that could come to dominate the research budget of NASA, a concern? I mean if you are going to do the space station, you have got to do it well, and you have to do it according to proper budgeting outlays. But will there be a price to be paid by not having sufficient money to do other things that you might want to, or is the answer perhaps to that yes, there will be, but frankly, this is simply more important, and therefore, it is worth more single shooting our research moneys for this purpose?

Mr. CULBERTSON. You should not measure our scientific activities strictly in terms of new starts. That is an easy measure, but it is not really a valid one, because we are deeply engaged right now in the present science programs that are under way and nearing fulfillment. As a matter of fact, this year's science budget was the biggest budget that science has enjoyed since the agency was formed.

Last year when we started this program we started a couple of new scientific initiatives. We were asked this question, and it is a perfectly logical question. We were asked this question, and our response was that we have looked at the outyears for this, and we believe that we can fit this into a wedge which allows us not to reduce the science program; in fact, it will remain a fairly constant part of the overall NASA program focused on science and technology.

Science and technology programs have grown more rapidly than any other part of the program in the last 7 or 8 years, and it is important that they do this. This will, in the peak of the development years, be the dominant program within NASA. But Mr. Beggs has structured us, structured the overall NASA program so that the science program will not fall below 20 percent or 20 to 25 percent of the total NASA R&D program. So the answer is no, the Space Station will not rape the science program.

Now, if we did not have this program could we put more money into science? I suppose that is true. But what this does do is provide a vast capability for the conduct of science in the 1990's. So we are using today's money to buy for tomorrow science programs, so we have been very conscious of that.

And you may recall that when the Space Science Board looked at the program a year and a half ago under the chairmanship of Dr. Donahue of the University of Michigan, the response was that science could not justify a space station, but that science could use a space station.

Now, we asked Dr. Donahue and the Science Board a year ago to do a 2-year study on the science program of the future, and they have given us some interim results of that, and we have, I think, largely due to Peter Banks and the work his committee is doing although some of the rest of us have participated, too, the scientific community is getting genuinely excited about the opportunities that are provided by the space station. Well, scientists do not get excited. They are becoming enthusiastic about the new opportunities that this provides for the science program. So I think it remains a balanced program.

Senator ROCKEFELLER. Thank you, sir.

Thank you, Mr. Chairman.

Senator TRIBLE [presiding]. Senator Rockefeller, we thank you.

Mr. Culbertson, I was intrigued by a question of the Senator from Michigan, because I thought it really presented a central question. In a day where we recognize there are limits on what government can do, it becomes all the more important to justify the expenditure of public moneys.

And indeed, it has fallen to us to tell the folks at Lookout Mountain, or Bluefield, or Grundy, VA, about these programs. And sometimes that calls for leadership of vision and a degree of courage, because it is not always easy to understand the importance of these programs back in our home communities.

But I thought your answer was a pretty good one, although I think a much more compelling case can be made than the one you advanced. It seems to me that in formulating that response you should point to the experience of NASA. You have every right to be proud of that experience. Through the years the payoff has been a huge one. The dollars expended by NASA have perhaps been the best dollars invested by our taxpayers in terms of improving the quality of life and in terms of providing economic opportunity. I am talking about jobs, and that is an important point.

Also, it seems to me that although this is harder to make this argument, it is the kind of thing that great nations do, and it has fallen to our generation to conquer the last frontier. And through the age of man there have been these frontiers. First the seas, then the air, and the atmosphere closest to Earth, and now to space, that it called on man to conquer.

And the nations that have stepped forth, that have expended time and money and energy and courage in doing so have realized tremendous benefits and have led the world. Not only have they been dominant in terms of military posture, but they have also been the prevalent economic force as well. So I thank you for your help in answering that question, because it is an important one.

In terms of the cost—and that is a substantial question—I must tell you it is my view that we ought to freeze spending across the board, and that would require that this program not be implemented quite as quickly, but it would permit us to continue what I think is an important program.

I know that over the past 2 years NASA has sought out and encouraged commercial interest, particularly in the nonaerospace sector in the space station. Bring us up to date on your progress. How much interest has been manifested to date? What are the principal barriers, as you see them, causing companies to delay or decide not to participate? What kind of financial commitment do you expect from these companies?

Mr. CULBERTSON. There are two kinds of participation in the program that I think we are talking about. One is can we get the private sector interested in investing its own money in developing some of the basic capability that sits on the table ahead of me.

The other part of it is, is the private sector going to spend its own money to develop uses of the space station. Let me address the first one, and that is the kind of thing, the participation that the private sector makes in the development of launch vehicles or the development of other kinds of basic hardware which enhance the capability of space.

We have not had any significant interest in providing pieces of the system that you see ahead of you. There is interest in providing for pieces of the platform or total platforms somewhat smaller than those we talk about, but still they are part of the overall structure. And there is one company which is proposing to develop a pressurized module on a free-flying spacecraft which could be used as a factory or production facility for commercial production of whatever.

The reason that it is difficult for people to envision developing parts of the system are that it is not obvious how they recover their money other than renting it back to the Government, and that turns out to be fundamentally just the same as the Government buying the product itself from a contractor.

Of course, contractors will do all of this fundamentally, but it is difficult for the venture capital people to understand how they can make significant investments in this hardware and get a return on the dollar because of the size of the system and the complexity of the integration of the system. That is not the case, however, in the potential use of the system. We are today working with 15 different companies who are investing their own money in the possible commercial use of space.

You are familiar probably with what 3M has been talking about, and it is the 3M's and the John Deeres and the Johnson & Johnson people. Now, there are more who are thinking about it, but there are 15 that actually are spending their own money on doing that now, and it is from those people that we are deriving requirements for the system so that when we build a system, it will satisfy the requirements.

Senator TRIBLE. I thank you.

Senator Gore.

Senator **Gore**. Thank you very much.

Let me just follow up on the last question that you asked about the RFP's. I was looking recently at a report by the California Institute, the California Space Institute, which you may be familiar with, and let me just read you what they say about this.

> The government procurement cycle is now itself a serious impediment to space station use of advanced technology. It is complex, difficult, slow and especially troublesome for prototype devices and development contracts. Smaller companies, often the leaders in automation and robotics, frequently decline to enter the process at all. In fast-moving areas, the procurement cycle can take longer than the technology's generation time and itself guarantees obsolescence in the installed hardware.

In other words, they are saying that the space station will not be able to use advanced technology unless NASA changes its procurement process. Would you agree with their assessment?

Mr. **Culbertson**. Not totally. I certainly agree that the Government has a cumbersome procurement process. I believe that NASA has probably spearheaded in more areas than any other Government agency the cutting of redtape in our procurement process. I am proud of NASA's record. I am not satisfied that NASA's record is good enough. It is not all of our doing. Some of it certainly is our own doing.

We are continuously trying to improve our process. So to that degree I agree with what Cal Space has said. To the degree that they say that because of these things, we will not be able to incorporate advanced technology in the space station, I do not agree with that, because NASA's programs have been full of advanced technologies, and we have ourselves advanced the technologies in a lot of different areas.

So do I agree with it? Not totally. Can we do better? Should we do better? Must we do better? The answer to that is yes.

Senator **Gore**. Well, does that require a legislative change or an administrative change?

Mr. **Culbertson**. I think it may require some legislative change, but we will do all that we can with the administrative change.

Senator **Gore**. Could you submit for the record at this point your recommendations for legislative change in this area?

Mr. **Culbertson**. I will look at that possibility. I do not personally have any, but let me go back to NASA and talk to our procurement people.

[The following information was subsequently received for the record:]

NASA procurement officials, have been concerned with the increasing complexity of the procurement process. Some of these concerns are with the lengthening of procurement lead times and the imposition of additional administrative burden on both the Government and private sector. The procurement process, in effect, serves two purposes—acquisition of goods and services, plus attainment of various socioeconomic objectives. The process now is controlled by over 4,000 legislative provisions and 3,000 pages of regulations. It appears that additional legislation, which will have an impact on the procurement process, is forthcoming.

As a result of the above concerns, NASA assisted in the drafting of P.L. 98-191, the Office of Federal Procurement Policy (OFPP) Act Amendments of 1983, which provides, among other things, that the OFPP Administrator may develop innovative procurement methods to be tested by selected Executive Agencies. If the Administrator determines that it is necessary to waive the application of any provision of law in order to carry out a proposed program to test, he may, with approval of the Congress, waive such provision. NASA believes this provision of the law offers an excellent opportunity to test new, innovative approaches in the acquisition of goods and services. There are several proposed tests being considered for approval by the Congress. NASA has volunteered to be a test agency in the area of small purchases.

We recently completed an acquisition lead time study which identified areas for improving and shortening the acquisition process. We have implemented many of the recommendations of an administrative nature that should make our procurement process more efficient and productive in terms of reducing lead times and administrative burden. We are concerned, however, that these gains may be offset by forthcoming legislation.

The Congress recently enacted three statutes that have a major impact on the Federal procurement process: P.L. 98-369, the Deficit Reduction Act of 1984 (Title VII of Division B, the Competition in Contracting Act of 1984, applies to procurement reform); P.L. 98-525, the Defense Procurement Reform Act of 1984; and P.L. 98-577, the Small Business and Federal Competition Enhancement Act of 1984. Inasmuch as most of the provisions of these statutes became effective April 1, 1985, sufficient data does not yet exist to make any credible analysis of their impact on such elements as lead time and productivity.

We will continue to explore ways in which we can improve our procurement process, especially in the area of acquisition of advance technology. Should we uncover any areas where we can improve the process, we will either correct it administratively or propose legislation.

Senator GORE. What kind of legislative changes do you think we ought to consider to improve the procurement cycle to make sure that the space station can use advanced technology?

Mr. CULBERTSON. I am really not prepared to answer that right now. Can I answer something for the record?

Senator GORE. Yes, you can.

Let me turn to another area. During last year's hearings the record indicates that NASA informed the committee that despite OMB's reduction of its fiscal year 1985 request from $235 million to $150 million, that it would still spend approximately $700 million for definition activities prior to the commencement of the phase C-D development activities.

Now the committee sees another reduction in definition activities in the fiscal year 1986 request. What is the current estimate of the NASA space station definition activities? Why has there been a $70 million reduction? Does this mean that NASA is going back to its old ways, underfunding definition activities at the risk of actually increasing the overall cost?

Mr. CULBERTSON. No. We have remained constant at the $700 million. As we read it today it is $711. We have not changed that. What we have done is adjust the schedule. When we first went to OMB with our request for the fiscal year 1985 budget we anticipated starting the contract definition studies last October, and as a result of that first cut, we stretched it until we started in January.

And as a result of the congressional action that was taken last year, in 1985 we stretched it until March, and now we are at April, and we do expect them to get started now.

But we did two things. We delayed the initiation of it, and we increased the period over which this definition would take place. We started with 18 months. Then in order to accommodate the $50 million reduction by OMB in the fiscal year 1986 budget, we stretched it to 21 months, and now we are looking at the possibility of 2 more weeks or something like that.

So, no, we have stuck to our guns since we started on this detailed definition; that it will take about $700 million. Whether we can keep that if we are significantly reduced this year is going to be—is going to get very tough now, because we have delayed it and stretched it about as far as sound planning would take it and take another look at it.

Senator GORE. Well, that is an encouraging response and a different response than given in the briefing 2 weeks ago when we received indication that it was going down to $630 million. Maybe there is some misunderstanding.

Mr. CULBERTSON. I do not know what briefing that was.

Senator GORE. In any event, I am glad you are not reducing the definition activities.

Now, let me go on to something I questioned Mr. Beggs on, and that is the confusion about whether or not there are one or two orbital maneuvering vehicles that are part of the IOC. For the record, I would like you to clarify this issue and at the same time will you indicate which accounts will bear the development cost of the orbiting maneuvering vehicles.

Mr. CULBERTSON. Our present plan is as follows. The orbiting maneuvering vehicle development costs will be borne by the space transportation system because that vehicle is needed by the shuttle for some of the servicing responsibilities and for some of the delivery responsibilities that it will have between now and 1992.

It is in the fiscal year 1986 budget in the space transportation system. I think there is a request for $25 million for the orbital maneuvering vehicle. Now, the present plan is that the space station would have one additional which would be based at the space station and, at the same time, the shuttle would retain one which it would be using. So you could say in that timeframe, it will be two.

I do not know whether we will find as we study this in greater detail that one is adequate for the space station, but that is the present plan, to have one. It will have to be modified, and so there will be some design responsibility and it has been in the budget to make some modifications to the one developed for the shuttle so that it is compatible with space basing at the space station and has what we would call a smart front end; that is, a highly advanced robotic front end so it could be used in a somewhat different way at the space station than the shuttle one.

Senator GORE. So it is one. Thank you.

One final question. There is a great deal of support for an interest in foreign participation in the Space Station Program, but there seem to be some concerns as well. Specifically, what is NASA doing to resolve the technical transfer issue dilemma? Can U.S. firms interact with foreign firms in compliance with existing U.S. trade and export laws, in particular as it concerns the exchange of technical data?

Will additional laws need to be enacted to facilitate the development of an international space station, and what efforts would or should be made to ensure access for countries other than our partners?

Mr. CULBERTSON. Let me address the partner situation first, and let me say what we are planning for that. I do not think there are any additional laws that are necessary. We have made it clear in our arrangements that we are not talking about a total open door on the transfer of technology. We will transfer those technologies which are necessary for them to make sure that the pieces they develop are compatible with the space station and that they fit.

We have discussed that level of technology transfer throughout the Administration and State Department and other areas that are concerned with technology transfer. And the agreements that we have reached with the Europeans and Japanese and Canadians are under final review within those departments now, and I believe they will go through.

We are acutely aware of the concern over transfer of technology. Other nations are, too. It is not just a one-sided thing. There will be technology discussed and transferred at the interfaces. We believe that we can satisfactorily control it to the satisfaction of the rest of the Government and our own interest, and control it at that level.

We have not considered really any need for technology transfer for other potential users, international users of the space station. We will have certain requirements which must be met in the use of the system and they will be the same requirements as we would place on ourselves. But there is not any real issue of technology transfer for other people using it. They will develop their own technologies. The Europeans will develop their own technologies for their systems, and they are proposing systems for which they are fully capable of developing their technologies.

The same for Japan and Canada.

Senator GORE. All right. Thank you, Mr. Culbertson.

Senator TRIBLE. Gentlemen, we thank you for your contribution today and we wish you well.

[The statement follows:]

STATEMENT OF PHILIP E. CULBERTSON, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE STATION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Distinguished Members of the Subcommittee:

Last year President Reagan directed NASA to develop a permanently-manned Space Station and to do so within a decade. Congress endorsed this initiative by providing the authority and funds to begin the initial planning. The program's goal, shared by both Congress and the President, is to assure United States leadership in space during the decade of the 1990's and beyond. In response to these mandates, NASA has set in place a Space Station Program that is substantial in scope and ambitious in character.

This morning I would like to review the program with you, explain the FY 1986 Space Station budget request and continue with Congress the dialogue on Space Station that we in the Agency have found extremely helpful.

The Space Station Program is characterized by a number of key features. Let me highlight three of them at this point:

- Detailed Definition - an extensive period of Space Station definition is essential. We must have a thorough understanding of technical, cost and schedule parameters before proceeding to hardware development. This approach of minimizing risk through detailed definition was a principal recommendation of a major study on Project Management NASA conducted in 1980;

- Customer Focus - the mission/payload requirements of the scientific, commercial and technology development communities that will utilize the diverse capabilities of the Space Station are paramount. We have incorporated them, and will continue to do so, in our technical planning and in our organizational arrangements;

- International Cooperation - President Reagan invited our friends and allies abroad to participate in the Space Station Program. The Space Station was on the agenda of the June 1984 London Economic Summit at which the Summit nations welcomed the U.S. invitation and acknowledged the benefits of such a program to technological and economic growth. Discussions with Europe, Canada and Japan have progressed significantly since we testified last year. We have reached agency-to-agency level agreement on the Memoranda of Understanding text with all partners. Final clearance procedure with the State Department is currently in process.

The Space Station is unlike any program NASA has undertaken, for it will be a permanent facility in space. No longer will we simply visit space. When the Space Station becomes operational we will be living and working in space around the clock, 365 days a year, well into the next century. The Space Station is also different because it is evolutionary in character. The initial baseline Space Station will have built-in the potential for phased, evolutionary development to meet future requirements.

This evolutionary character and the permanent nature of the Space Station make the undertaking truly unique. They place a new and difficult engineering challenge upon NASA and her industrial partners. But the rewards will be great, for the Space Station will significantly enhance United States capabilities to operate in space.

The Space Station will consist of a manned base and associated platforms, as well as collateral support equipment. Incorporating both manned and unmanned systems, the station will advance the technologies of automation and robotics. In this regard, I want to emphasize the importance we place upon automation and robotics. Congress has directed us to examine the potential for utilizing the Space Station to advance the technologies of automation and robotics. In my view, the potential is significant, although it should be realized that NASA programs typically emphasize automation and robotics and that an enhancement of these technologies beyond what we would ordinarily do would require funds not currently included in our program plan. NASA has established an Advanced Technology Advisory Committee which has completed its report. This report has been submitted to Congress and will be given to our Phase B contractors. It provides the basis for understanding how Space Station planning and the technologies of automation and robotics can be merged and enhanced.

The Space Shuttle, whose capability for frequent and routine manned access to Earth orbit makes the very idea of a Space Station viable and attractive, will play a key role in Space Station development and operations. The Shuttle will carry the station elements into Space and help assemble them on orbit. It will be used as a test vehicle for the development of Space Station technologies. In conjunction with Spacelab, the Shuttle will provide valuable operational experience for the Space Station user communities. The Space Shuttle will, of course, be used for Space Station logistics and crew rotation once it becomes operational.

The Space Station will be a versatile and effective facility, serving a diverse range of functions. It will be:

- a national laboratory in space, for the conduct of science as well as the development of new technologies and related commercial products;
    - a permanent observatory, to look down upon the Earth and out into the universe;
    - a servicing facility where payloads and spacecraft are resupplied, maintained, upgraded and, if necessary, repaired;
    - a transportation node where payloads and vehicles are stationed, processed and propelled to their destinations;
    - an assembly facility where, due to ample time on orbit and the presence of appropriate equipment, large structures are put together and checked out;
    - a manufacturing facility where human resourcefulness and the servicing capability of the Station combine to enhance commercial opportunities in space;
    - a storage depot where payloads and parts are kept on orbit for subsequent deployment; and
    - a staging base for future endeavors in space.

The Space Station will also be:

- a striking example of Free World unity and capabilities; and
- a highly visible yet peaceful demonstration of U.S. leadership.

During the past year NASA has set in place a number of activities that are central to understanding the Space Station Program upon which we've embarked. A complex, technical effort of Space Station definition and preliminary design, "Phase B", has been initiated with U.S. industry. Phase B studies are scheduled to begin formally on April 15th of this year. Central to the detailed definition phase of the program, they will provide NASA, the Administration and Congress with the necessary data upon which to scope the hardware development phase. The Phase B analysis will incorporate the man-tended studies that Congress directed us to conduct. In addition, the analysis will utilize the report of the Advanced Technology Advisory Committee which examined the potential for the Space Station Program to both fully utilize and enhance the technologies of automation and robotics. Our contractors understand the importance we place upon these studies and will be directed to consider carefully both the man-tended approach and the potential for automation and robotics.

The Phase B analysis will be keyed to the user requirements that we have studied extensively over the past 2-1/2 years. These requirements are a primary driver of Space Station design. They will be continuously refined and updated throughout the life of the program.

Recently, NASA selected six industry teams for negotiations leading to fixed-price contracts for the Phase B definition and preliminary design analysis. The responsible NASA Center and the teams selected for negotiations are:

Marshall Space Flight Center, Huntsville, AL--Boeing Aerospace Co., Seattle; and Martin Marietta Aerospace, Denver.

Goddard Space Flight Center, Greenbelt, MD--RCA Astro Electronics, Princeton, NJ; and General Electric Co., Space Systems Division, Philadelphia.

Lewis Research Center, Cleveland, OH--Rockwell International, Rocketdyne Division, Canoga Park, CA; and TRW Federal Systems Division, Redondo Beach, CA.

In addition, NASA will negotiate with Lockheed Missiles and Space Co., Sunnyvale, CA; McDonnell Douglas Astronautics Co., Huntington Beach, CA; and Rockwell International, Space Station Systems Division, Downey, CA; the three proposers for work to be performed under the management of the Johnson Space Center, Houston, TX. Following negotiations, a report will be presented to the NASA Administrator who will then award one or more contracts. We expect that all of the Phase B contracts will commence on April 15.

Concurrently, with this emphasis upon user requirements and the Phase B definition and preliminary design studies, we have initiated a major program of technology development. Later on, I will discuss this in greater detail, but I want to say here that the development of advanced technological options for the Space Station is an activity of the highest priority, one to which we are devoting substantial resources. Within NASA we are working closely with the Office of Aeronautics and Space Technology to assure a balanced and effective technology program.

To implement the many activities of the Space Station Program, we have established a management structure which, as the Subcommittee knows, features a three-tiered allocation of responsibility. Level A here at NASA Headquarters in Washington is responsible for the policy and the overall direction of the program. Level B, located at the Johnson Space Center in Houston, is responsible for program management and the technical content of the program. Level B is also responsible for integrating the work of the Level C centers which are responsible for discrete project elements.

Our program plan envisions a 21 month (April 1985 - January 1987) Phase B definition and preliminary design effort with the hardware development phase, or "Phase C/D," beginning in FY 1987. This constitutes a slight adjustment to earlier plans that showed an 18 month Phase B. Early in 1986, we will conduct a series of technical reviews that will result in the definition of a Space Station baseline configuration to which the rest of the Phase B analysis will be directed. These reviews are major milestones in our definition program and will include U.S. industry as well as our potential international partners. At the end of the Phase B activity, scheduled for early in 1987, we will begin the competition for Phase C/D.

This program plan assumes a strong role for NASA in program management and provides genuine competition among U.S. industry. It is compatible with meaningful international participation in the Space Station Program. It gives a strong voice to the Space Station user communities and establishes a significant effort in technology development. Most importantly the Space Station program plan will be based on a detailed definition that is, in my view, the only way we can assure credible cost, schedule and technical projections. And finally, it is a plan that will enable NASA to meet the goal set by the President of developing America's permanently manned Space Station within a decade. I am here this morning to ask your support of it and for the resources necessary in FY 1986 to move the program forward.

Our budget request for FY 1986 is $230 million. Of this amount $15 million is for Utilization, $82 million is for Advanced Development, $52 million is for Program Management/Integration, $7 million is for Operational Readiness (this is a new budget line this fiscal year), and $74 million is for System Definition (Phase B contracts). Attached to my statement is a chart that summarizes this request and shows funding for previous years.

The following describes the major elements of our budget request and some of the consideration and criteria used in developing these requirements.

Utilization

In FY 1986, a total of $15 million is planned for the definition of Space Station utilization requirements. To fulfill our commitment to make the Space Station user friendly, we consider the requirements of the users to be the fundamental justification of the Space Station. Therefore, their needs establish the basis for the Space Station's capabilities. We have worked with and will continue to work with several hundred potential users, studying how their dozens of sometimes conflicting critical requirements will be accommodated by a Space Station that must serve many disciplines and many nations with pressurized modules, attached payloads and associated platforms, including at least one platform in polar-orbit. At present, these users have identified over 300 potential missions or payloads. When the priorities of the sponsors of these activities are considered, it is already clear that a large fraction of the proposals will require early accommodation aboard Space Station systems. These users are variously in the commercial sector; in the technology development community; and in the science and applications communities both national and international.

One of the major goals of NASA is to expand opportunities for U.S. private sector investment and involvement in civil space and space-related activities. The Utilization program has established an active and strong voice to reflect this goal within the Space Station Program and to seek out those commercial enterprises which might profit from using the Space Station. In this regard, we are cooperating with the NASA Office of Commercial Programs. We will also seek the advice and counsel of the NASA Advisory Council's Task Force on the Commercial Use of Space.

The emergence of the Space Station as a major NASA endeavor opens the potential for in-space research and technology development of much greater scope than in the past. Thus, system design criteria must be established to enable the Space Station to function as a research and technology facility. This is being accomplished in cooperation with NASA's Office of Aeronautics and Space Technology by considering special technology needs for end-of-the-century NASA missions and for the unique in-space capabilities that the Space Station will provide.

Space science activities and the civil operational applications, whether commercial or governmental, are developing into a strong set of demands on

Station capability. We have made good progress already during FY 1985 in codifying the intentions of our potential foreign partners, and of other agencies, such as the National Oceanic and Atmospheric Administration. Within NASA, the Office of Space Science and Applications has developed a specific set of intended uses of the manned element and the associated platforms as part of its normal planning activities for the coming years. For example, the Office is planning for the proposed Earth Observing System (EOS), a collection of instruments and sensors for the Space Station polar platform which will observe critical parameters of the Earth and its environment.

As part of the Agency's continuous effort to involve the users in all phases of Space Station design, development, and construction, NASA established the Task Force on Scientific Uses of the Space Station, chaired by Dr. Peter Banks of Stanford University, The Task Force is a derivative of the NASA Advisory Council's Space and Earth Science Advisory Committee. Its membership includes scientists representing all of the major disciplines, i.e., astronomy, astrophysics, life sciences, planetary exploration, earth observations, microgravity science and information systems. Its responsibility is to counsel NASA on plans for, and work in progress on, the scientific utilization of new capabilities that will be afforded by the Space Station. The Task Force has met several times and has presented a number of strongly argued recommendations. A report on its week-long summer study last August is in final preparation. Although NASA may not be able to act on all the recommendations of the Task Force, the group has been extremely effective and will continue to be of great value to the program.

We also seek advice from the Space Science Board. The Board is an activity of the National Research Council of the National Academy of Science and the National Academy of Engineering and serves as their focus of interest and responsibility in space science. It is conducting a special, two-year study of scientific use of the Space Station in the late 1990's and beyond.

Our Space Station utilization effort is critical for the coming fiscal year to get the design effort started in the right direction. In FY 1985, we are emphasizing the top level functional requirements that will shape the Phase B definition and preliminary design activity. In FY 1986, the interplay between users and the Space Station definition effort will be refined as we start the process of determining how to accommodate each of the user's specific requirements. We will also start the process of determining ways of extanding the life of specific space assets by the use of the Space Station for servicing.

Servicing, in fact, will be one of the most valuable capabilities of the initial Space Station. The Hubble Space Telescope, for example, could be refurbished and serviced at the station avoiding a costly return to Earth. Other proposed projects such as the Advanced X-Ray Astrophysics Facility (AXAF), and the Gamma Ray Observatory (GRO) may also be refurbished and serviced at the Space Station. We will continue to study what specific servicing can best be conducted from the Space Station and to what extent robotics can be used to enhance the effectiveness of EVA crew hours.

The major area of expansion in utilization activities in FY 1986 will be in the development of mechanisms to provide consistent and user-friendly interfaces throughout the user's experience with the Station. These will include easy access to arrange for providing services, provisioning, replenishment of consummables, and the retrieval of products, including both scientific and technical data. In keeping with the recommendation of the Banks committee, we will place special emphasis on user information systems that will accommodate a broad spectrum of users.

Commercial Participation

We have established several roles for potential private investment and involvement in the Space Station Program. The private sector could participate as a builder, operator or a user. A builder would participate in the definition and development programs and contribute to the capabilities of the Space Station. An operator would support the program in the operational phase. A user would define missions and utilize the Space Station's capabilities.

Since 1982, our principal activity regarding commercial participation has been with users. Although there has been some private sector interest in a builder role for free-flying platforms these are not formally part of the Space Station Program. However, we believe there can be a role for the private sector in building, with private capital, elements of the Space Station. We plan to better understand what might be done to encourage such commercial participation. In this, we will work closely with the NASA Office of Commercial Programs in order to assure that we do not establish precedents that could adversely affect the private sector's future in space. Any policy established must enable the evolution of a free, competitive marketplace.

Advanced Development

The Advanced Development Program is intended to provide technology design options for the Space Station. Within this program, selected high leverage generic technologies are focused for Space Station and are matured to a prototype level in order to demonstrate their feasibility, establish their performance, and quantify the risks (cost and schedule) associated with their potential introduction into the Space Station development effort. This selection and focusing process for technology options is being performed in cooperation with the Office of Aeronautics and Space Technology and is built upon a generic base of space technology developed by that office. This program has been initiated in FY 1985 and will be continued throughout the definition phase so that we can be sure of the technologies that we determine to be appropriate to carry into system development. In FY 1986, a total of $82 million is requested to turn these concepts into prototype hardware and to conduct the necessary tests and evaluation. To accomplish this, NASA has established a series of technology test beds at our field centers to quantify and validate the performance of advanced components and subsystems in a ground laboratory environment. Evaluation and testing of some of these technologies has already been initiated in a number of major discipline areas including: attitude control and stabilization, power, thermal, environmental control and life support, auxiliary propulsion, data management, structures and mechanisms.

In FY 1985, the test beds were put in place to evaluate the more mature elements of technology through early tests of brassboard type hardware. In FY 1986, the test beds will be expanded to accommodate additional brassboard tests as well as testing of prototype level hardware and system evaluation.

During FY 1986 we will continue, in cooperation with other NASA program offices, the development of several Shuttle based flight experiments in areas that are not only important to early development of technology for the initial Space Station but also have application to other space activities and which require testing in the space environment. Experiments planned for Shuttle flights in 1986 include the verification of high power solar array technology, the measurement of atomic oxygen effects on materials, the testing of two-phase thermal pump and radiator systems, and the demonstration of erectable structural systems. As the test bed activities identify promising technologies that need to be tested on-orbit, other flight experiments will be carried out to support the development program.

Program Management/Integration

The major components of our $52 million request for Program Management and Integration are the System Engineering and Integration (SE&I) effort and the Technical and Management Information System (TMIS). SE&I for the Space Station Program is intended to be primarily a NASA in-house effort with support from industry for some specialized technical studies and for certain administrative support tasks. The TMIS is a program wide information system with the basic objectives of improving the productivity of individuals and facilitating program integration tasks.

The FY 1985 SE&I effort is focused at preparing for the beginning of the definition and preliminary design effort. A Systems Engineering and Integration organization has been established at Level B, and organizational relationships between Levels B and C are being established. Analytical tools are being developed and special studies are underway leading to subsystems design requirements. Technical panels are being instituted to coordinate discipline oriented output of trade studies, an engineering master schedule is being developed to orchestrate the design process, and a data base is being constructed for the exchange of technical details.

In merging both the technical and managerial requirements into a single system, the TMIS becomes the backbone of communication, coordination, and information transfer. TMIS is essential to undertaking and completing systems engineering and integration, and it is the fundamental instrument for gathering, transmitting, analyzing, and presenting the information employed in program management. We have initiated incremental development of the system that is consistent with our program phasing.

System Definition

Our definition phase contracted efforts get underway this month. The Space Station Program will begin a 21 month period during which engineering information will grow in detail as our options are focused to a single design. Throughout this process, contractor teams in support of each work package will be working to conduct trade studies examining a variety of options for the Space Station design. In mid FY 1986, as an outcome of the Systems Requirement Review, we will select a Space Station baseline configuration. Subsequent to this, preliminary design of the Space Station will commence and extend into the first quarter of FY 1987. These contractor studies will be managed by Level C centers while Level B will have the principal responsibility for tying them together to produce a single integrated system design. The FY 1986 funding increment requested for this system definition effort is $74 million.

Two special topics are being addressed as part of the Phase B definition and preliminary design analysis--the man tended approach and the subject of automation and robotics. Both topics are of particular Congressional interest. The question of how the permanently manned feature of the Space Station can be phased in over a period of three to five years will be worked in all facets of the definition. We will report back to Congress on the man-tended approach, as required by law. The automation and robotics plan will outline an approach to incorporate appropriate advanced technologies in the Space Station. As mentioned earlier, this plan will be given to the Phase B contractors and be utilized in their activities.

Operational Readiness

In FY 1986 we are requesting $7 million for Operational Readiness. The operations activities are directed to insuring the readiness of the Space Station Program to conduct a continuum of scientific, technological, and commercial missions. The Space Station represents a new opportunity to develop space operations as an ongoing, routine activity with the flexibility to take full advantages of new technologies and scientific discoveries as they surely will occur. The program will draw both on industry for detailed ground and space systems design and upon NASA's long and broad experience in manned and unmanned operations to develop the overall operation concepts.

Operationally, the Space Station Program differs from previous NASA programs in several aspects. First is the necessity to routinely integrate Space Station and payload systems on orbit, rather than on the ground prior to flight, in order to support a wide range of varying and different missions. New techniques will be required to verify electrical and mechanical interfaces and functional relationships where one part of the hardware is on orbit and its component piece of hardware is being developed on the ground.

Additionally, we must develop a logistic system that periodically provides the Space Station with consummables, spare parts, payloads and people. The logistic system must also support the provisioning for the platforms on a regular basis.
In FY 1985 we are developing operating concepts for the launch, orbital, and logistics systems. Our in-house effort to date has resulted in preliminary operational requirements and plans. These will be incorporated in the Phase B studies. These requirements and plans scope the ground based facilities requirements and systems design, and Space Station system operational characteristics. Contractor analysis and NASA studies are being used to complete the overall Space Station operations concept that will take full advantage of NASA's expertise and institutional base. The operational concept must include mechanisms for international operations. A multinational Operational Concept Working Group will be established to coordinate operational and planning studies.

In FY 1986 the operational requirements will be established and preliminary design and definition studies will be initiated for the various ground systems that support the Space Station operations. These studies will develop systems requirements for our prelaunch, orbital, logistics, and payload operational activities. They will be closely coupled with the Space Station Phase B studies. The results of these operational studies and the Phase B analysis will be integrated by NASA's operational staff at Level B and will lead to the preliminary design and definition of the ground operation system. This is expected to be completed by the start of Phase C/D in FY 1987.

Program Organization and Management

Mr. Chairman, as you know, in response to the President's directive to establish, within a decade, a permanently manned Space Station, the NASA Administrator established the Office of Space Station to implement the program. This is the first opportunity we've had, as a program office, to present testimony to you. As I mentioned earlier in my statement, we have established a three-tiered allocation of responsibility to manage the Space Station Program.

Let me comment briefly on Level A. The Level A Space Station Office is responsible for providing overall program direction and top-level requirements definition. It is also responsible for technical, budgetary, schedule and cost controls as well as operations planning, advanced systems and strategic planning, top-level engineering oversight and international and commercial policies and plans. We have set out an organizational structure for Level A which is shown in the chart attached to my statement. The Office is now almost completely staffed and I am delighted to say we have a first-rate team on board.

The total approach to Space Station management was detailed in a report entitled "Space Station Management Plan and Procurement Strategy." The report was delivered to Congress in December 1984. In addition to extensive organizational and managerial material, the report contains a discussion of the procurement strategies and the rationale for the method selected for implementation.

International Activities

Mr. Chairman, let me conclude this statement with some comments about the international dimensions of the Space Station Program.

President Reagan's Space Station charge to NASA also included a call to friends and allies of the United States to participate in the program to "strengthen peace, build prosperity and expand freedom for all who share our goals." The President reaffirmed this invitation at the London Economic Summit where he explained the Space Station Program to the leaders of the participating countries.

As we testified last year, the potential of international cooperation in the program has been a primary planning criteria from the outset, and in the 1982-1983 time frame we encouraged potential partners to perform their own mission analysis activities. Such analysis activities were undertaken in Canada, Europe, and Japan. The results have been exchanged and updated in a continuing series of workshops. All inputs, including ours, are now being updated prior to the initiation of definition studies. The commitment to long-term utilization of Space Station capabilities is a primary guideline for international partnership in the program. The NASA reference configuration developed as a point of departure of our definition studies has been shared with potential partners and each has been specifically requested to inform NASA of the reference configuration(s) which they currently envision for the elements which they will analyze in their own Phase B studies.

In order to further coordinate predefinition activities and share status information, additional workshops were held in Washington, D.C., last year at which preliminary guidelines for international cooperation in the program were presented by NASA and discussed with officials from ESA, Great Britain, France, Germany, Italy, Canada, and Japan. At the last workshop, a proposed set of technical guidelines for the program was also presented and discussed. These will be discussed further and evolve as we proceed. At each of the workshops a major theme has been the necessity to coordinate Phase B studies on compatible schedules in order that information will be available on all elements of the initial Space Station at the time it is baselined early next year.

The guidelines for international cooperation in the Space Station Program are based upon those successfully followed in more than 25 years of cooperative international activities. The unique, long-term nature of the Space Station Program, however, has given rise to several significant criteria. Reference has already been made to the requirement that international partners have long-term requirements to utilize Space Station capabilities. The fact that this program will span several decades dictates that a true partnership must incorporate on all sides a commitment to utilize the Station. It is envisioned that the ownership and responsibility for sustaining engineering of internationally provided elements will rest primarily with the international partner.

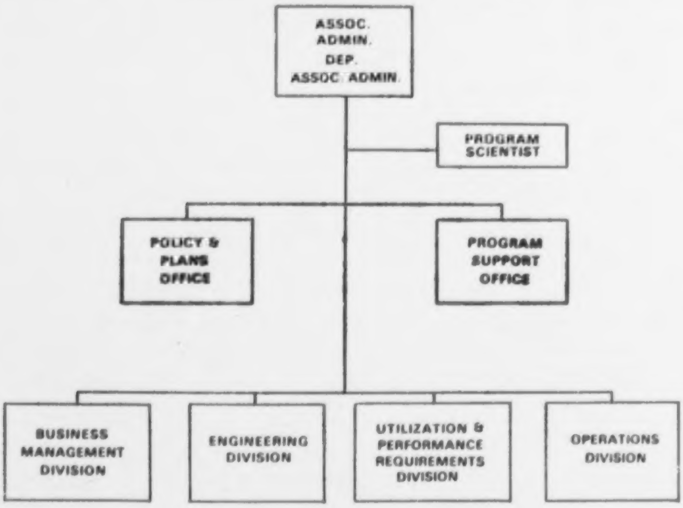
As stated earlier, agreement in the form of Memoranda of Understanding (MOU) to coordinate activities during Phase B have been negotiated and an agency-to-agency level agreement has been reached with all partners. The MOUs set the framework for cooperation during this phase. In addition, they will establish a process to identify elements for the initial Space Station which could be developed by international partners. The financial and technical responsibility for the international components of both Phase B and Phase C/D rests with the participating countries.

I can report, at this time, that a number of Space Station elements are under consideration by potential partners as candidates for international development. The ESA Space Station Program declaration includes the study of pressurized modules, unmanned payload carriers, and ground support facilities. Canada has reported its intention to study construction and servicing facilities, solar arrays, and remote sensing facilities. Japan is studying the concept of a multi-purpose experiment module. Each of these potential investments, if realized, would add significantly to the capabilities of the Space Station. They could lay the basis for long-term, mutually beneficial partnerships in the Space Station Program.

Conclusion

We have embarked upon a new challenge that will enable the United States to achieve a new level of capability in space. The Space Station will provide a permanent human presence in orbit around the Earth. It will be a truly versatile facility, one that will expand the frontiers of knowledge, push the development of technology and stimulate commercial enterprises in space. The Space Station will demonstrate to the world our intention to remain the leading nation in space while, at the same time, promoting international cooperation with our friends and allies. President Reagan's directive has set NASA on a course to meet that challenge. We have begun the task. With the continued support of Congress we will be able to make significant progress this year and in the years ahead.

OFFICE OF SPACE STATION


ASSOC. ADMIN.
DEP. ASSOC. ADMIN.
PROGRAM SCIENTIST
POLICY & PLANS OFFICE
PROGRAM SUPPORT OFFICE
BUSINESS MANAGEMENT DIVISION
ENGINEERING DIVISION
UTILIZATION & PERFORMANCE REQUIREMENTS DIVISION
OPERATIONS DIVISION

OFFICE OF SPACE STATION
FY 1986 CONGRESSIONAL BUDGET
INITIAL DEFINITION
(REAL YEAR $ IN MILLIONS)

	FY 1984	FY 1985	FY 1986
UTILIZATION	4.1	9.0	15.0
ADVANCED DEVELOPMENT	6.9	52.3	82.0
PROGRAM MANAGEMENT/ INTEGRATION	5.4	33.7	52.0
OPERATIONAL READINESS	--	3.0	7.0
SYSTEM DEFINITION	5.5	52.0	74.0
TOTAL	21.9*	150.0	230.0

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* Funded as part of the Office of Space Flight ($13.0 million), Office of Aeronautics and Space Technology ($6.0 million), Office of Space Science and Applications ($2.0 million), and Office of Space Tracking and Data Systems ($0.9 million).

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Space Station

IMPACT ON FREEZE ON SPACE STATION PROGRAM

Question 1: What risks would be imposed on the program with a funding level in FY 1986 of less than $230 million?

Answer 1: There would be some increase in risk above the baseline program although the program would be restructured to minimize risk as much as possible. The program schedule would undoubtedly be affected. The degree of schedule slip would depend on the severity of the reduction.

However, if possible, the $230 million level should be maintained. 1986 is the second year of a three year definition program and we should proceed to complete that process in an efficient manner. The Phase B contractors are on-board and their teams are beginning to assist us in defining the system options and in participating in our advanced development tasks. It is clearly much more efficient to complete this definition effort as currently planned. It is also extremely important to maintain the program balance between systems definition, functional requirements and technology studies if we are to develop the Space Station that is not only the best we can obtain with our resources, but one that can take advantage of technology improvements now and in the future.

INTERNATIONAL ASPECTS OF SPACE STATION

Question 2: How and to what extent will NASA determine the technologies or elements that the international participants will ultimately contribute? To what extent will there be allowed duplication or overlap in the systems developed by different countries?

Answer 2: NASA is currently finalizing agreements with ESA, Canada, and Japan in the form of Memoranda of Understanding (MOU's). These MOUs cover only activities during the two-year definition phase and are intended to coordinate the study activities of all of the partners and to establish a mechanism to determine which Space Station elements each of the partners will carry into preliminary design. The Space Station elements provided by our international partners will become part of the initial capability for use by all partners. This approach is intended to minimize unnecessary duplication of effort and facilities and thereby maximize the facilities and capabilities intended by the Space Station at IOC. Each partner will be responsible for both the financial and technical aspects of their projects.

Question 3: In his testimony before this Subcommittee, Jim Beggs said that annual operating costs will be in the neighborhood of $500 million.

How has this figure been determined, and what are the principal drivers that could increase this cost? What are some of the options under consideration for sharing operational costs? What can and will be done to control operating costs so that they don't "strangle" NASA's other ongoing and proposed programs?

Answer 3: When Mr. Beggs testified as to annual operating costs, he was careful to preface his estimate with the statement that NASA had not yet arrived at a hard figure for operations. He further qualified his estimate of operating costs "in the several hundred million dollar a year category, perhaps a half a billion dollars a year for basic operation" by indicating that this was only a "top of the head guess" that should not be taken as a hard figure because NASA had yet to define it.

NASA is very sensitive as to the manner in which overall systems design, operating philosophy and system utilization effect operating costs. We are beginning to define some cursory operational scenarios, including proposed participation by the international community, to determine their impact on operational requirements. The actual design and operation of the Space Station will reflect studied considerations of important cost drivers such as systems reliability, division of duties (ground versus space), technology availability, automation and logistics.

The nature and extent of cooperation and participation by the international community and by potential commercial entities is in the early stages of definition, and policies relating to the manner in which operational costs would be shared have not yet been proffered.

Question 4: Will the elements of the IOC, both U.S. and non-U.S., be deployed exclusively on the Shuttle, or will some of these elements be deployed from Ariane? Will the U.S. be expected to utilize all of the European systems, including the French shuttle Hermes (pronounced HERmeez), when they become operational?

Answer 4: While it is clear that the Space Shuttle will constitute the primary means of access to the Space Station for the United States, it is understood that international partners may choose also to use their own means of access. The European Space Agency, for example, will be studying access to the Station through European systems such as the Ariane expendable launch vehicle. There are no plans for the United States to utilize European transportation systems. Therefore, neither the Ariane or Hermes are now considered to be part of the overall cooperative program.

Question 5: What are the concerns of both NASA and ESA concerning ESA's desire for "non-discriminatory access" to all elements of the Space Station?

Answer 5: We have told our international partners that all cooperative participants in the Space Station Program will have access to the full range of Space Station capabilities. We have not begun negotiations with ESA or our other partners on detailing the specifics of that access, but this is one of the elements of the Phase C, D, and E negotiations. In fact, we have reflected this in the current NASA ESA Phase B MOU, stating that principles regarding access to and use of all elements of the Space Station on a basis which provides for equitable and nondiscriminatory treatment for all partners is a matter which needs to be agreed to.

CO-ORBITING AND POLAR PLATFORMS

Question 6: I understand that there is substantial interest in the polar platform that will be associated with the Space Station. What is the likelihood that there will be more than one U.S. polar platform in the initial operating capability (IOC) or that a second polar platform would be commercial in nature? How likely is it that Great Britain will contribute a polar platform?

Answer 6: There is a current interest for a large number of polar platforms early on, and the various potential user sponsors are holding serious discussions, both intra- and inter-agency, to see if user needs can be satisfied by not only shared platforms but also by shared instruments. This activity is welcomed as pre-new start discussions for any of the potential payloads. Until new starts occur, until synergistic usage discussions release new ideas, and until further definition of the Space Station occurs, it cannot be determined how many polar platforms there will be.

Contributions of a polar platform by ESA and Great Britain have been part of discussions between NASA and other foreign agencies, but there is likely to be no final decisions on foreign elements until NASA is ready to start Phase C/D activity. It has been NASA's position that all Space Station facilities are to be shared.

SPACE STATION REQUIREMENTS OF THE SPACE SHUTTLE FLEET

Question 7: How would the deployment and operation of the Space Station be affected if one of the Orbiters were taken out of service for a significant period of time?

Answer 7: Logistics and payload delivery to the Space Station are, of course, critical to the effectiveness of the Space Station operations. Loss of an orbiter would probably affect these operations. However, until a manifest analysis is made by the Space Shuttle program, a definitive answer cannot be given.

COMMERCIAL ASPECTS OF SPACE STATION

Question 8: How many commercial modules and free-flying platforms do you expect in the IOC, and what types of activities do you expect to be conducted on these first commercial Space

Station endeavors? What would be the likely composition of these commercial elements?

Answer 8: We have been having discussions with representatives of various U.S. industrial concerns regarding commercial provision of co-orbiting and/or polar spacecraft. It is too early, however, for firm payloads or elements to be identified. Industry has not yet been able to discuss definitive plans with us.

ESA currently has proposed two co-orbiting platforms during IOC for the automated production of materials for industrial and commercial purposes and for research in exo- and radiation biology.

COMMERCIAL ASPECTS OF SPACE STATION

Question 9: How do you plan to resolve the conflict that might arise when a foreign country or company seeks to compete with U.S. companies in the development or operation of a Space Station element or system?

Answer 9: Decisions on which country develops a Space Station element or system will be the subject of negotiations between NASA and our international partners. NASA intends that basic Space Station systems will be developed within the United States. Foreign development of Station systems will be compatible with this intention. In regard to operational responsibilities, scheduling of the use of capabilities provided by the Space Station is a subject that requires considerable analysis. Our intent is that the Station's capabilities will be available to any of the partners who participated in the development.

Question 10: How will the commercial requirements of power and proprietary data influence the Space Station design?

Answer 10: A large part of the commercial production is focused on materials processing. The overall area of materials processing, including research & development, is the most demanding area of the currently stated power requirements. We are studying during Phase B an IOC Space Station design which will permit rapid response in provision of this amount of electrical power as firmer plans for commercial activity materialize.

We have discussed with industry their requirements for protection of proprietary data. Their requirements appear to be satisfied by commercially available equipment which the Space Station Program would provide. Additional protection would be provided by the users. This permits each user to determine the level of protection which his activity requires.

Question 11: To what extent does the power tower framework allow for additional commercial and international elements beyond the IOC?

Answer 11: The "power tower" reference configuration is a design which allows the evolution of the Space Station to accommodate additional commercial and international elements beyond those included in the initial operational capability (IOC). This concept of evolution has been a basic management guideline from the inception of Space Station planning. The final IOC configuration from the Phase B studies will be assessed for its capability to evolve and meet these long-term requirements.

MAN-TENDED OPTION

Question 12: Could you establish a man-tended facility that could evolve to a manned facility simply by deploying the power tower framework with unpressurized modules? What are the additional costs and risks associated with developing a man-tended facility that later evolves to a manned facility, compared to initially developing a manned facility?

Answer 12: There are several options for designing a Space Station which defers installation of the permanently manned features for a period of three to five years. We have directed our contractors to identify these options and to examine their possible implementation approaches. From the results of these efforts we intend to develop an understanding of the additional technical and programmatic risks and cost incurred by taking such an approach. It would be premature to guess at this time what those impacts might be.

POWER SYSTEM FOR SPACE STATION

Question 13: I understand there are two primary power options under consideration for space station - photovoltaic and solar dynamic. Can you tell us what specific criteria will be used in making a selection? What are the comparative costs of developing either system? What are the obstacles to developing a solar dynamic power system in time for the Space Station's IOC?

Answer 13: During the Space Station Phase B studies, system engineering studies will be conducted by both contractors and NASA in-house personnel to compare the two power options with respect to all aspects of system design. The final selection will be based on the results of these studies. The major discriminators are expected to be:

- cost (initial and life cycle)
- size (power per unit area)
- growth capability
- level of technology readiness

Other factors that will impact the selection will include maintainability, ease of assembly, reliability and other factors relating to manufacture, deployment and operations.

Due to the different levels of technology readiness of the two systems (solar dynamic power systems have only been developed for terrestrial applications), no comparative cost data are available at present. These data will be developed during Phase B.

The major technical challenges in the development of a solar dynamic power system for space applications are in the area of energy collection and storage. Finding the technical solutions in a timely manner at an affordable cost represent the major obstacles to deployment of such a power system at the time of the Space Station's IOC.

Question 14: If a solar dynamic power system can be developed by the IOC, are there any reasons for developing the solar photovoltaic power system?

Answer 14: Based on presently available data it appears that if a solar dynamic power system were selected for IOC, it would supply the Space Station for normal operations but emergency power would probably be provided by a photovoltaic system. In addition, even if a solar dynamic system were selected for the manned Space Station, the platforms may still be powered by a photovoltaic system. With these uncertainties regarding the use of solar dynamic power systems, it is wise to continue a thoughtful photovoltaic power program.

Question 15: By what date will a decision be made of either the photovoltaic or the solar dynamic system for IOC?

Answer 15: The decision on the selection of the power system is likely to be made before the end of the definition and preliminary design phase. A firm date will be established once the data from the Interface Requirements Review (IRR) are available, nine months after Contract Start Date.

Question 16: I understand that there are some specific advantages of the solar dynamic option - for instance growth potential. If this is the case, what is NASA doing to ensure that this option is being vigorously and expeditiously pursued?

Answer 16: The growth potential of the solar dynamic power system is indeed of great advantage. Recognizing this, NASA is vigorously pursuing the advancement of component technologies through the Space Station Advanced Development Program. Present plans call for funding nearly $18 million on solar dynamic power system technology.

Question 17: If photovoltaic is selected for IOC what specific plans does NASA have for phasing in the solar dynamic system to allow for growth?

Answer 17: One of the major tasks to be accomplished during Phase B is to define the growth version of the Space Station. The definition will include the total power, the method of growth, the increments and the plan to be followed to accomplish growth. For example, should a photovoltaic power system be chosen for IOC the plans will include recommendations to include specific features into the Space Station design which will enable the change-over to a solar dynamic system, and then permit the addition of units to increase power. The plan is also expected to include those features of the power management and distribution system (as well as other impacted subsystems) that will enable accommodation of the increases in power.

Question 18: Could you comment on the possibility of developing a nuclear power system for the Space Station, when such a system might be available and for what cost? What are the advantages and disadvantages of a nuclear system of this nature?

Answer 18: Present projections of Space Station utilization call for approximately 300 kilowatts by the end of the century. These power requirements are expected to be met by an advanced solar dynamic power system. Beyond that point the very high power density (power per unit area) of a nuclear power system might well present a viable alternative. At present plans are being formulated by the Departments of Defense and Energy to develop a ground engineering system of a space nuclear reactor power system for unmanned military applications as a follow-on to the Tri-Agency (NASA/DOE/DOD) technology (SP-100) program. It is estimated that the cost for that program will be $250M - 450M over five years. NASA will continue applications and cost studies as well as participate in the advancement of selected technologies during that phase. If a high power need for Space Station is shown during that time, it is expected that a flight unit might be built in another 5-6 years, making it available for deployment in the 1996-98 time frame. The unit cost of such a system would depend on the success of the ground engineering phase and cannot be estimated reliably at this time.

SPACE SCIENCE AND THE SPACE STATION

Question 19: One concern of the Banks Committee is that there have not been and will not be enough Shuttle/Spacelab flight opportunities to develop an adequate basis of experience for the conduct of human-assisted research aboard the Space Station. Is this concern justified, and if so, what is NASA doing to correct this problem?

Answer 19: During the early shuttle operations era, shuttle flight opportunities for science and applications did occur at a lower rate than we would have hoped for. However, ongoing improvements in the STS are resulting in increased capability and flexibility to handle current and potential payload requirements. For example, the fourth orbiter is planned to be online later this year; and additional launch pads will be operational at both Vandenberg and KSC in 1986. Within the current STS manifest baseline, we see essentially a doubling of flight opportunities in the FY 1985-88 period for science and applications. As a result of continuing close coordination between the Office of Space Flight (OSF) and Office of Space Science and Application (OSSA), all approved science and application payloads have been accommodated within the current manifest baseline, except for a life sciences mission. We hope that this remaining manifest issue can be satisfactorily resolved. Examples of near-term (FY 1985) opportunities include two dedicated shuttle flights - one for microgravity sciences (Spacelab-3) and one for physics and astronomy (Spacelab 2).

Question 20: Do you think that all of NASA's ongoing and future space science research programs are adequate to allow for Space Station scientific research that fully utilizes the unique capabilities of a Space Station?

Answer 20: NASA's Office of Space Science and Applications (OSSA) has discussed extensively with our staff the characteristics of representative activities which might use all of the elements of Space Station, and which ones are realistic to assume could be supported at projected future funding levels. In virtually every major space science and application discipline, they have identified candidate activities that address established space research objectives while taking advantage of the potential capabilities of the Space Station. OSSA's planned programs utilize every aspect of the Space Station including servicing. Many of the capabilities being designed into the Space Station complex reflect their needs.

THE USE OF TELESCIENCE WITH THE SPACE STATION

Question 21: The Banks Committee has recommended that a communications mode called "telescience" be utilized as a means of providing effective interaction between the Space Station and the scientific investigators at their home base. What is the feasibility of this system being developed by the Space Station IOC and what are the associated costs?

Answer 21: The telescience concept is not new to NASA. A few current, unmanned missions are operated from the researcher's home facility right now. Two such examples are the AMPTE real time data link and chemical release operations operated from the Applied Physics Lab in Maryland, and the Solar Mesosphere Explorer operated from the University of Colorado. Thus, the concept is technically feasible and proven. It should be noted, however, that some technical challenges are anticipated given the volume of data projected for some Space Station payloads and the impact of data security measures.

No cost data has yet been gathered for the present telescience type operations nor has such costing been done for the projected Space Station Information System. We will define the data system design and associated cost estimated as an inherent part of the Phase B studies.

Question 22: What are the benefits of this system compared to other communications modes that might also allow interaction between the Space Station and the scientific investigators?

Answer 22: The benefits of telescience as compared to other communications modes are:

- o Reduces cost to the investigator for doing business;
- o Logistics impacts are reduced;
- o More effective utilization of the investigator's capabilities

The traditional mode used by NASA for investigators to interact with payloads is to require the scientific investigators come to a centralized Payload Operations Control Center, probably located at one of the NASA field centers. This approach has inherent inconveniences and expenses including the inefficiencies of having to recreate many of the scientist's analysis tools (hardware and software) at a general purpose control location.

However, those are balanced by the savings associated with a centralized facility providing a set of standard services. It is possible that technology has shifted the balance towards telescience. This will be subject to study in the coming year.

AUTOMATION AND ROBOTICS RECOMMENDATIONS OF NASA'S ADVANCED TECHNOLOGY ADVISORY COMMITTEE

Question 23: What factors will determine which of the recommendations of the Advanced Technology Advisory Committee will be implemented on the IOC of the Space Station?

Answer 23: NASA is developing an implementation plan that will be presented to the Phase B contractors for their guidance in fulfilling the recommendations of the ATAC. Key factors include cost, technical readiness and applicability to planned IOC capabilities.

Question 24: Which of these recommendations are most likely to be implemented, and how will they be implemented into the Phase B contracts and into the Space Station development?

Answer 24: We will not know specifically which of the recommendations would most likely be implemented until we assess the automation/robotics plan that will be derived by the Phase B contractors. Our current assessment indicates that a dexterous manipulator on the Space Station will be required to effect the initial assembly. We further believe that the Orbiting Maneuvering Vehicle (OMV) must include sensors and effectors so that the OMV can function in a teleoperated mode. This will probably be required to effect the satellite maintenance and repair function of the Space Station. We are also convinced, as a result of the contractors' proposals, that expert systems could be incorporated in many subsystems to effect an automatic maintenance and repair capability aboard the Space Station itself.

Question 25: What is your assessment of the differences between the recommendations of the Advanced Technology Advisory Committee and those of the Cal Space Study?

Answer 25: The only significant difference in the recommendations made in the Cal Space Study and those made in the Advanced Technology Advisory Committee (ATAC) report regards the funding of automation and robotics technology efforts. The Cal Space Study recommended the establishment within NASA of a separate budget for basic and applied research in automation and robotics, while the ATAC report did not address this topic. All other recommendations made in the two reports were in relative agreement.

SPACE STATION MISSIONS

Question 26: How many potential missions have been identified to date for the initial operating capability for the Space Station, and to what extent have the potential international partners contributed to this Space Station mission model?

Answer 26: In addition to on-going mission requirements analyses in the United States, our potential partners have been deeply involved in the process of identifying Space Station mission requirements. ESA, Japan, and Canada have conducted mission requirements studies in their respective countries in the same timeframe as the U.S. studies. All potential partners participated in Mission Requirements Workshops conducted last year and updated requirements are now included in the Space Station Mission Data Base maintained at the Langley Research Center. Currently, over 300 entries are included in the Space Station user data base of approximately 75 have been provided by the potential international participants.

Question 27: How will NASA and its international partners determine which missions will be conducted -- what factors will determine if a particular mission is chosen?

Answer 27: International partners with significant investments will have a role in the overall management and operation of the Space Station. This will include a role in the selection and time-phasing of specific missions. The role will be commensurate with the size and nature of the investment but it is as yet too early to provide details of the manifesting process.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS

Space Station

TECHNOLOGY DEVELOPMENT

Approximately 50 percent of the Space Station definition activities are geared to advanced technology development.

Question 1: What is the focus of the NASA advanced technology development program--reducing life cycle cost? Eliminating routine and hazardous tasks? Reducing ground support requirements? Please "prioritize" the goals of this program for the record.

Answer 1: The advanced development program of the NASA Space Station is focused upon evaluation and development of technologies that have potential to enhance Space Station performance capabilities and to lower program costs and risks. This program will provide viable technology candidates for hardware and software systems before the development phase. Some of the high priority goals of the advanced development program are:

o Develop techniques which will enhance the capabilities of the initial operational capability (IOC) Space Station and understand the development cost implications, operational cost savings, and risk factors associated with incorporating these technologies.

o Assess the role of advanced technologies in the potential future growth of the Space Station and adapt the design of the IOC Station to accommodate their incorporation at a later date.

o Define and develop those technologies leading toward the evolutionary Space Station.

Question 2: Why is NASA terminating advanced technology development activities at the end of the definition phase? Won't the evolutionary nature of the Space Station and the goal of a fully automated Space Station require continuous technology development?

Answer 2: The evolutionary and growth aspects of the Space Station Program indeed require a system capability beyond the current state of the art. To advance the leading edge of technologies for growth applications, NASA maintains a continuing generic research and technology program managed by the Agency's Office of Aeronautics and Space Technology (OAST). When NASA defines the potential approach to Space Station incremental growth, inherent in this definition will be an evolutionary growth strategy. At that time, appropriate elements of the generic research and technology program of OAST will be focused on specific Space Station technology requirements.

The current Space Station Program and OSS budget are concentrated upon the definition, design, evaluation and development of the initial operational capability (IOC) Space Station. The current advanced development budget is focused on technologies to be incorporated in the IOC Space Station which can be completed in time for inclusion in the design and construction phase of program. The IOC design will also incorporate required subsystem accommodation features to provide for evolutionary growth in both automation level and overall capabilities in subsequent configurations. Focused evolutionary advanced development activities will commence after Space Station growth modes and the required enabling advanced technologies have been defined and selected.

Question 3: Why is NASA focusing on advancing existing technologies? Doesn't the space station represent any major technological breakthroughs.

Answer 3: The NASA Space Station advanced technology program focuses the continuing Agency generic base of research onto specific, near-term needs of the IOC Space Station scheduled for the early 1990's. The IOC Station will be based upon the technologies which will be mature and well understood at the beginning of the design and development phase scheduled for FY 1987. Since this schedule allows only a few years to conduct an advanced development program, relativity mature, high-leverage technologies are selected for early completion.

The Space Station will be designed to be a multi-functional asset in space for the foreseeable future. Therefore, from an overall systems viewpoint, the Space Station presents a major technological challenge. The Space Station will incorporate achievable advances in near-term technology in the IOC Space Station. The advanced development program focuses upon breakthrough technologies in many disciplines and matures them into practical, spaceborne hardware systems. As technologies mature and major breakthroughs are achieved, these technologies will be assessed and, when appropriate, will be incorporated into the Space Station configuration.

Question 4: What technologies would you expect to be the pacing items in the development of the Station, i.e. which technologies required will be the most difficult to develop?

Answer 4: We expect the pacing technologies in the design and development phase of the Space Station to be those technologies which have the potential for the greatest leverage on performance, cost, or schedule. These technologies will have the highest leverage independent of the IOC design and subsequent growth configurations; contribute substantially to a more efficient and capable Space Station; avoid technological obsolescence; and provide improved capabilities for users of the Space Station. Examples of pacing technologies include:

o solar dynamic power generation; adaptation of current terrestrial-based solar-dynamic technology into a mature space borne system;

o automation and robotics; obtaining the optimum mix between man, automation, and robotics to enhance the quality, quantity, and application of crew time;

o data management architecture; designing the most efficient system to accommodate rapid and diverse changes in this expanding technology; and,

o thermal transfer via two-phase fluid; development of advanced heat transfer techniques into high-capacity systems to meet Station and user needs.

Question 5: Two of the major accomplishments of NASA to date have been the Apollo and Shuttle programs. For the record, would you provide the initial cost estimate of these programs compared to final cost? Did these two programs represent any major technological breakthroughs? Shouldn't a similar standard be established for the Space Station?

Answer 5: The initial design, development, test and evaluation (DDT&E) cost estimate of the Apollo program was $20.0 billion in early-1960's dollars. The final cost of the Apollo program was $21.3 billion in mid-1960's dollars. The initial DDT&E cost estimate for the Shuttle was $5.2 billion in FY 1971 dollars and the final cost was $6.7 billion in FY 1971 dollars.

Both the Apollo and the Space Shuttle programs required many major technology breakthroughs. A few of the most prominent Apollo program breakthroughs include: large-rocket technology, orbital and rendezvous mechanics, reentry dynamics, ablative material, computer technology, and spaceborne life-support systems. The Space Shuttle enabling technology breakthroughs include: large oxygen/hydrogen engines development and reusable thermal-protection ceramics.

Unlike the Apollo and Shuttle programs, a Space Station could be built with today's technology. Something like this was previously accomplished in 1973 under the Skylab Program. However, such a station would not possess attributes enabling on-orbit maintenance, reduced operating costs, continuing growth, and indefinite lifetime. The Space Station advanced development program will adapt recent technology breakthroughs and mature them into practical spaceborne systems. In the course of our definition and preliminary design phase activities, we will be developing recommendations to include design provisions to accommodate future breakthroughs as they become available in areas such as automation and robotics. By permitting persons to live and work permanently in space, the Space Station will be a facility to enable new technological breakthroughs by the users of the Space Station in a wide range of space applications and sciences.

Question 6: Why hasn't the Space Station Office taken a similar approach to the development of the Space Station? What "role" do you see for the private sector to build elements of the Space Station with private capital? Couldn't NASA promote the commercial development of the power or information systems, the space platforms or other components and then lease or contract for them in a manner similar to the space platform RFP?

Answer 6: Because of the complex technical, managerial, international, and financial requirements it does not presently appear to be feasible for the private sector to assume the overall responsibility for the Space Station.

However, NASA is promoting participation by the private sector in the Space Station Program. NASA is defining guidelines for commercial cooperation where a builder can participate in the Space Station definition and development program, and contribute to station capabilities. An operator role is one where a commercial entity can perform functions in the operational phase. Finally, commercial users would define missions and utilize station capabilities. It is possible for cooperative commercial partners to have all three roles. NASA will encourage the private sector and will evaluate commercial proposals on a case-by-case basis.

Question 7: Upon entering the Commercial Era of Space, shouldn't NASA see the commercial sector as more than a "user" of services? Doesn't the private sector development of various components reduce the overall cost to the U.S. Treasury, as well as stimulate the commercial potential of space?

Answer 7: As noted in the answer to Question 6 above, NASA does view the private sector as more than a user. NASA's Office of Commercial Programs and its policy on the Commercial Use of Space are some prime examples of our attempts to encourage private sector participation in our national civil space program. Commercial ventures will be considered where a savings to the U.S. taxpayer is possible. Examples of past efforts are McDonnell/Douglas' Payload Assist Module (PAM) and Orbital Science Corporation's Transfer Orbit Stage (TOS). In these cases, the financial risk of development was assumed by the private sector entities. At this point in the Space Station program, it is not clear what the Station configuration will be and what specific opportunities are available to the private sector. We are developing appropriate policy to assure that the private sector has an opportunity to independently develop components for the Space Station.

Question 8: In your prepared statement you indicate that your office has worked with several hundred potential users and has tried to determine how to accommodate their "sometimes conflicting critical requirements" in the space station. How many of these "users" have made recommendations to NASA that would make the space station more "user friendly"? Can the IOC configuration outlined by NASA respond to the various demands of the user communities?

Answer 8: We have been working with the potential user community to determine what resource capability (e.g. electrical power, volume, data handling, crew, etc.) the Space Station must provide in order to make their proposed activity possible. In this process, we have also been asking about other requirements which would influence the design of the Space Station elements (e.g. stability, proprietary data transmission, sustained microgravity, real time interaction between scientists on the ground and the on-orbit experiment). Often, these requirements are stated so that their fulfillment will make the Space Station more "user friendly" than prior spacecraft. In addition, during the dialogues to establish the requirements, the users had the opportunity to make recommendations of features which they considered would increase "user friendliness" (e.g. less paperwork). We are working to incorporate as many of these features as possible. We have not kept a record of how many users made such suggestions. We believe that the individual user requirements can be satisfied by the currently outlined IOC capability. We also believe that a major fraction of the proposed activities can be accommodated simultaneously. The fraction varies according to which combinations of activities are considered.

MANPOWER REQUIREMENTS

Question 9: Last year NASA supplied the Committee with a Space Station - In House Manpower Table broken down by space and research centers. Could you provide the most recent Space Station manpower levels for the Committee? Are you confident that NASA can handle the Systems Engineering and Integration (SE&I) responsibilities?

Answer 9: Following is a summary of the in-house manpower by Center supporting the Space Station Program.

SPACE STATION
IN-HOUSE MANPOWER
FY 1986 CONGRESSIONAL BUDGET REQUEST

CENTER	FY 1984	FY 1985	FY 1986
ARC	--	13	14
GSFC	25	80	113
HQ	39	72	72
JSC	189	513	620
KSC	60	185	366
LaRC	--	50	50
LeRC	--	155	205
MSFC	117	256	390
NSTL	--	--	--
TOTALS	430	1,324	1,830

We are confident that the SE&I responsibilities can be managed by NASA.

Senator TRIBLE. Mr. Ian Pryke, director of the Washington Office of the European Space Agency.

Gentlemen, you are most welcome. Mr. Pryke, we have your statement and we will make that a part of the record. You are invited to read your statement or summarize your statement. Thank you for your presence, and perhaps you could introduce for the record the gentleman at your side.

STATEMENT OF IAN PRYKE, HEAD OF WASHINGTON OFFICE, EUROPEAN SPACE AGENCY, ACCOMPANIED BY DR. MOE KHINE, SPACE STATION TECHNICAL REPRESENTATIVE

Mr. PRYKE. Yes, thank you, Mr. Chairman. I am accompanied here today by Dr. Moe Khine, the ESA Space Station technical representative based at our Washington office, who maintains day-to-day liaison with the NASA Space Station Program.

First let me thank you on behalf of the agency's director general, Professor Luest, for inviting the agency to testify once again in the course of your deliberations on NASA's budget request. Professor Luest asks me to express his regrets at not being here in person, but his schedule proved to be incompatible with the new hearing date.

Today's hearing relates to the space station. However, to put this testimony in the correct context, I will briefly summarize the outcome of the meeting of the ESA council, held at ministerial, last January.

The ministers, taking into consideration that the agency has successfully completed or is in the process of completing a number of major programs originally approved in 1973, in particular spacelab and Ariane; that a new long-term plan for space activities in Europe had been proposed; and that the President of the United States had invited Europe to participate in the Space Station Program, recognized that the present scope of the agency's programs had to be enlarged within a coherent, complete, and balanced long-term European space plan to meet the challenges of the next decade and beyond.

The main aims of the policy for the envisaged period are to expand Europe's autonomous capability and Europe's competitiveness in all sectors of space activity, as well as to enhance and to strengthen the partnership with the United States.

They therefore approved a number of decisions that are described in the council resolutions of the long-term space plan and on participation in the Space Station Program. Mr. Chairman, it had been our intention to attach these resolutions to the copies of the testimony we delivered today. By an oversight, we did not do this. I would therefore request permission to submit a copy for the record.

Senator TRIBLE. That will be accepted and welcomed as part of the record.

Mr. PRYKE. As these will be part of the record, I will only therefore address those portions that relate to space station cooperation within. Within the resolutions of the council, and I quote: welcomes and accepts the invitation by the President of the United States of

America to participate in the space station with a view to continuing and strengthening a genuine partnership in the space field, provided that certain fundamental objectives which are listed in the resolution, on the participation in the space station program, are achieved; and welcomes and endorses the proposal to undertake the Columbus program as a significant part of an international space station program.

Though these and equally positive decisions in other program areas, the ESA council has shown that the European states show a common view of Europe's future in space and that there is political resolve to enable Europe to improve its already strong position among world space powers.

When President Reagan made in his offer in January 1984 to the friends and allies of the United States to participate in the space station program, Europe could look back on a decade of intense collaboration with NASA in manned space-flight, through the highly successful Spacelab Program, Europe's contribution to the U.S. Space Transportation System.

During this period, Europe has learned a lot, not only in the technical and managerial field, but also as regards difficulties which are naturally inherent in such a major program of cooperation, and how to cope with them.

For about 3 years now, ESA has carried out space station related studies financed out of an ESA special program known as the Space Transportation Systems long-term preparatory program.

Studies have also been undertaken by the German and Italian Governments, and more recently by the British Government. The objective was to prepare for decisions on Europe's role in the building of space station elements.

On June 28, 1984, the ESA Council approved a resolution on the execution of a space station related preparatory program, Columbus. In the ESA institutional setup, this means that the Council representing the member States agrees to the carrying out of an optional program within the framework of the agency.

A declaration on the Columbus Preparatory Program was drawn up on the November 20, 1984. This declaration sets out the undertakings of the participating States in detail. The declaration took effect on January 30, 1985, and covers a 2-year period, with an approved funding of approximately $72 million—1983 dollars.

The objective of the Columbus Preparatory Program is to study all elements identified under the Columbus Program, some of which may be retained for a cooperative participation in the U.S. space station system and to develop supporting technologies for the early phase of the Columbus Program. It will run in parallel with the NASA phase B studies.

The technical content of the preparatory program is outlined in the testimony, and I will therefore not repeat it here.

The preparatory program will be divided into two phases. The first one, called phase B1, running from May 1985 to February 1986, will involve study of the various technical solutions and options with the aim of identifying among them the space station element or elements that the agency will propose to NASA as the European contribution to the cooperative program.

The second phase, B2, will be devoted to completing the definition studies of and the completion of, the phase C/D proposals for the space station element or elements jointly agreed with NASA for development, subject to satisfactory negotiation of the terms and conditions for the subsequent program.

Management relationships will be set up to ensure technical liaison with NASA and coordination of studies in accordance with the instructions of our participating States.

As I have already said in my introductory remarks, the ESA Council welcomed and accepted the offer by President Reagan with a view to continuing and strengthening a genuine space flight partnership with the United States within the framework of the European long-term space program, subject to achieving the following fundamental objectives—and I quote here from the Council resolution:

One, to seek an appropriate European participation by the agency in the Space Station Program;

Two, to give Europe responsibility for the design, development, exploitation, and evolution of one or several identifiable elements of the space station, together with the responsibility for their management with the aim of increasing the overall capability of the space station;

Three, to ensure that Europe may have access to and use of, on a nondiscriminatory basis, all elements of the space station system on terms that are as favorable as those granted to the most favored users, and on a reciprocal basis;

Four, to reach a satisfactory agreement on the share of the operational costs of the station;

Five, to reach a satisfactory agreement on the level and on the conditions for the appropriate transfers of technologies;

Sixth, to ensure that supplies and services provided by the U.S. industry and NASA for European requirements are offset by European supplies and services;

Seven, to ensure maximum legal security and an identical level of commitments entered into by the European governments and the U.S. Government; and finally

Eight, to guarantee the availability of the American transportation and communications facilities required for the program and the possibility of using the European facilities as they become available for the program.

These fundamental objectives, as endorsed by the Ministers, are an expression of the results of the learning process inherent in the decade of spacelab cooperation with NASA which I mentioned earlier.

The discussion of such basic principles for governing our cooperation during phases C/D and E, and which therefore will have to be an integral part of the legal instruments covering those phases, will have to start in the near future.

Coming back to present events, I can inform the subcommittee that the language in the ESA/NASA space station phase B MOU is now finalized. Our negotiations with NASA have been open and frank. Some of the solutions found for the phase B MOU are adopted to the particular phase B situation only and cannot necessarily be carried forward to phases C/D and E. They will therefore be the subject of future negotiations. We expect, however, that the existing text will carry us through phase B without encountering major problems.

As previously mentioned, ESA will run space station phase B studies during 1985 and 1986 in parallel and in close cooperation with NASA's phase B activities. We are currently planning studies involving a pressurized module, co-orbiting and polar-orbit platforms, a resource module, and a servicing vehicle, among others. At the end of phase B1, which will occur in late 1985, a decision will be made on those elements to be proposed to NASA for evaluation within the cooperative context.

By way of a conclusion, Mr. Chairman, I will quote from the closing remarks of the testimony originally prepared for Professor Luest to deliver--and I quote:

> In the interest of the longstanding, excellent cooperation between the United States and Europe in civil space activities, I felt it to be useful to explain to you in some detail the reasoning of my member States' governments when they have to decide on Europe's participation in the Space Station program. I am looking forward with great confidence to our further collaboration which will also strengthen the ties between the United States and Europe. In this way we are able to demonstrate to the world that we can cooperate in such a challenging endeavor as the Space Station.
>
> President Reagan's invitation to Europe to participate in the Space Station program has had a very positive impact in shaping and achieving the agreement on a long-term program of ESA. And I would like to take this opportunity to formally acknowledge this fact.
>
> In conclusion, I would like to express my thanks to the United States and especially to NASA for the help they have given to Europe and for the very fine collaboration for more than 20 years which will constitute an excellent basis for the future.

Thank you, Mr. Chairman. That concludes my testimony.

[The attachment referred to follows:]

EUROPEAN SPACE AGENCY COUNCIL RESOLUTION ON PARTICIPATION IN THE SPACE STATION PROGRAMME

(Adopted on January 31, 1985)

The Council, meeting at Ministerial level,

Considering the offer made by the President of the United States in January 1984 to the friends and allies of the United States of America to participate in the space station programme which he has instructed NASA to carry out within the next decade,

Considering the availability of an orbital station represents a decisive phase in the exploration and use of space for peaceful purposes,

Recalling the implementation of the Spacelab programme and the first Spacelab flight which took place in 1983,

Recalling that a number of Member States have undertaken with the framework of the Agency, a Spacelab follow-on development programme and a long term space transportation systems preparatory programme (ESA/C/LIV/Res. 1 (Final)),

Having regard to Resolution ESA/C/LXIV/Res. 4 (Final) of 28 June 1984 on the execution of a space-station-related Columbus preparatory programme and the corresponding Declaration,

Considering that participation in the space station programme constitutes one of the elements of the long term plan of the Agency (ESA/C-M/LXVII Res. 1 (Final)),

Considering that the object of participation in this programme is to expand the horizon for space research and exploitation, to master the new technology needed for carrying of manned and unmanned orbital operations in low Earth orbit and thus to permit the future development of a European in-orbiting infrastructure,

Noting the drawing up by NASA and the Agency of a Memorandum of Understanding determining the modalities of their cooperation with a view to harmonised conduct of their respective detailed definition activities for the space station, Having regard to the document on negotiations with the United States (ESA/C-M(85)3),

I. Welcomes the offer by the President of the United States of America;

II. Accepts that offer—with a view to continuing and strengthening a genuine partnership in the space field with the United States of America and within the framework of the European Long Term Space Programme and the objectives defined in it—subject to the achievement of the following fundamental objectives: to seek an appropriate European participation by the Agency in the space station programme; to give Europe responsibility for the design, development, exploitation and evolution of one or several indentifiable elements of the space station together with the responsibility for their management with the aim of increasing overall capability of the space station; to ensure that Europe may have access to and use, on a non-discriminatory basis, all elements of the space station system on terms that are as favourable as those granted to the most-favoured users and on a reciprocal basis; to reach a satisfactory agreement on the share of the operation costs of the station; to reach a satisfactory agreement on the level and on the conditions for the appropriate transfers of technologies; to ensure that supplies and services provided by the United States industry and NASA for European requirements are offset by European supplies and services; to ensure maximum legal security and an identical level of the commitments entered into by the European Governments and the United States Government; to guarantee the availability of the American transportation and communication facilities required for the programme and the possibility of using the European facilities as they become available for the programme.

III. Invites the Member States and the Director General to set up suitable machinery under Council authority for drawing up and negotiating the legal instruments with the United States Government and with NASA for the development and utilisation phases of the space station.

IV. Agrees that the ESA Council will review the progress of the negotiations in order to reach a decision with regard to the undertaking of the development, production and utilisation phases of the space station programme before the end of 1986.

Senator GORTON [presiding]. We want to thank you and, of course, the European Space Agency for that cooperation as well. It has genuinely been a two-way street.

My first question relates to that, relates to the relationship between this space station and the Columbus space station project.

How long will ESA allow its contributions to the U.S. space station to remain as a part of that infrastructure? Does it intend, if it goes ahead with Columbus, to move them to its space station?

Mr. PRYKE. Our current planning in the Columbus Program calls for the contribution of certain elements from that program to the U.S. space station. It is true, the European Space Agency's long-term plan does keep open an option for the eventual autonomous operation of a European space station. However, that is not to say that should we choose to operate a station autonomously, we would withdraw the elements we have already contributed to the U.S. space station.

Senator GORTON. It is perfectly conceivable that you would do both at the same time?

Mr. PRYKE. It is conceivable we would do both; yes.

Senator GORTON. What kind of timeframe do you think is required first for the decision as to whether or not Columbus will be built; and second, if it is built, when it will be operational?

Mr. PRYKE. We will be carrying out the so-called Columbus Preparatory Program which is our phase B in parallel and in the same timeframe as NASA. So around about the time NASA is looking for the go ahead from the U.S. Government for U.S. component of the space station, we will be looking to our members States for a go ahead on our Columbus Program, including those elements that we will contribute.

Senator GORTON. You expect that it is more likely than not that the go ahead will be received?

Mr. PRYKE. We have already received from our member states, through the Council meeting at Ministerial level, an agreement in principle on the total program package, with a funding of—I believe it comes out at $2.1 billion. We have only received the full authorization for a phase B for the spending, as I mentioned in the testimony, of about $72 billion in 1983 dollars.

Senator GORTON. $72 billion?

Mr. PRYKE. $72 million. Sorry.

Senator GORTON. How does ESA expect to reach a satisfactory agreement on the precise elements that it will develop and contribute to space station IOC?

Mr. PRYKE. We will be studying within the preparatory program all elements of Columbus and these studies will then form the data base that will allow us to propose to NASA certain elements for a European contribution to the space station, and we will then enter into negotiations with NASA on those proposal.

Senator GORTON. One of your objectives in participating in the Space Station Program is to give ESA nondiscriminatory access to all elements of the system on terms as favorable as those granted to the most favored user.

Could you interpret this objective as it relates to the protection of proprietary data?

Mr. PRYKE. We do not see a conflict here, Mr. Chairman. The nondiscriminatory access to the total space station infrastructure we consider to be a fundamental principle as far as participation is concerned. We do recognize, however, that in the implementation of that fundamental principle, regard will have to be taken to the question of proprietary data that will be generated on the space station.

This will be something that will have to be addressed not only from the U.S. side, but also from the European side.

Senator GORTON. That was my next question. According to your testimony, ESA will participate in the U.S. Space Station Program as long as it can reach a satisfactory agreement with respect to technology transfer.

What are the requirements for a satisfactory agreement?

Mr. PRYKE. I would say they are, Mr. Chairman, that this is certainly going to be a difficult issue. We have had a lot of discussions with NASA on technology transfer as regards the negotiation of the phase B MOU. And as we mention in the testimony, we have now come up with language that we think covers the issue for the phase B period.

We do recognize that technology transfer is going to be a very difficult problem that will have to be addressed within the program, and we expect to have negotiations with the United States over the next couple of years on the matter. I think we do note, or as a personal perspective I would say I seem to find a growing awareness in the states that technology transfer on such a program has become a two-way issue. And I think this will certainly help when we sit down to address the problem.

Senator **Gorton**. Speaking just a moment to the satisfactory agreement on sharing of operational costs, what would constitute that?

Mr. **Pryke**. I think as Mr. Culbertson mentioned, this is something that all the international participants are very interested in. We will be looking into the question of operating costs, as will NASA. I think the studies have not progressed far enough at this time to really have a good idea of what those operating costs will be. Until we have a good idea of what those operating costs will be, it will be very hard to discuss a partition of them.

Senator **Gorton**. Thank you very much, Mr. Pryke. We appreciate your testimony.

Both I and, I suspect, other members of the committee may wish to submit other additional questions in writing to which we would appreciate your responses.

Mr. **Pryke**. Thank you, Mr. Chairman.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. There is a great deal of discussion concerning freezing NASA's FY 1986 funding level at the FY 1985 level.

If this were to occur, and the space station funding were less than the Administration's request of $230 million, how would this affect ESA's plans to participate in the space station program?

Answer. Although running in parallel and carefully coordinated, the Phase B studies of ESA and NASA are independent. Funding for the two year Columbus Preparatory Programme is already approved and ESA would therefore proceed as planned with its studies, even if a budget freeze in the U.S. slowed NASA's planning. Some revision of the coordination and decision processes as defined in the MOU would of course, have to be made.

Question. Under what circumstances would ESA decide not to participate in the U.S. space station program?

Answer. If agreement, with the U.S., on certain fundamental principles relating to cooperation, as described in the ESA Council's "Resolution on Participation in the Space Station Programme", annexed to the testimony, could not be reached, the ESA member states would have to decide whether or not they would opt to participate in the U.S. space station program.

Question. According to your testimony, ESA will seek to have its facilities used in the space station program as they become available.

What are these facilities you have in mind, when will they be available and to what extent would you expect them to be used?

How and to what do you expect the Ariane ELV to be used in the space station programme?

Answer. The facilities referred to in the referenced portion of the testimony are:

Ariane 5 ESA's recently approved ELV development, that will have a payload capability to Low Earth Orbit of approximately half a shuttle payload bay. Studies in Europe and discussion with NASA indicate that the vehicle could have a potential to provide logistics support to the space station infrastructure.

A potential "European Data Relay System" currently under study, that could be operated in support of the basic space station infrastructure, and polar platforms.

The Hermes manned vehicle currently being studied by CNES which would have the potential to be used for logisitics support, crew changeout etc.

Current planning calls for these capabilities to become available around the mid-1990's.

Question. How early in the program would you expect to use one of your Ariane vehicles?

Answer. As mentioned previously, development of the Ariane 5 vehicle will be completed in the mid-90's. Its use within the space station programme is under study but no specific time for a first "operational mission" (within the programme) has yet been identified.

Question. According to your testimony, some of the solutions for the Phase B MOU are adapted to the Phase B agreement only and cannot be carried forward to the development phases C/D and E.

What are some of these solutions and why would they not be applicable to the development phases of C/D and E?

Answer. A number of sensitive issues (e.g. technology transfer) addressed in the Space Station Phase B MOU will require further assessment as regards the subsequent phases of the programme. Some solutions achieved in the wording of the Phase B MOU were general in nature. In the C/D and E phases of the programme, when the contribution ESA will be making to the space station infrastructure has been clearly defined, the language in the agreement covering these phases may have to be more specific.

In a more general context, a MOU between ESA and NASA was considered sufficient for cooperation during phase B studies. As regards the C/D and E phases, agreement has still to be reached between Europe and the U.S. as to the type of agreement that will be entered into.

Question. What are the problems related to the integration of ESA's technologies to those of the U.S.?

What is a suitable resolution of these problems?

Answer. With an adequate exchange of interface data, and other relevant information, between ESA and NASA, within the space station programme, the physical integration of European and U.S. technologies should not pose any major problems. (As was demonstrated in the Spacelab programme.) The issue of commonality of certain hardware to be developed by both parties, and utilisation of facilities (.e.g, test beds) will be addressed in the early phases of the cooperation.

Question. According to your testimony, ESA has decided to build the free-flying statellite, Eureca, which the Shuttle will deploy.

(A) When do you plan to deploy Eureca and what will be its primary functions and capabilities?

Answer. The first mission of Eureca is currently manifested on the Shuttie for deployment in March 1938, and retrieval approximately six months later. The primary function of Eureca is to provide a platform to support the in-orbit operation of experiments that require longer running times (on the order of months) than can be provided by the Shuttle, but are not candidates for placing on an autonomous satellite. The Eureca Mark I can carry a payload of up to 1000 Kilograms and supply it with 1 Kilowatt of power.

The first mission payload will consist mainly of microgravity experiments but will carry a couple of experiments in other disciplines to demonstrate the multidisciplinary character of the system.

Question. Do you intend to establish Eureca as part of the U.S. space station?

Answer. The Eureca Mark I is not planned for inclusion in the space station infrastructure. The use of some form of "Eureca derviative" is a matter to be determined in the course of the Phase B studies.

Question. Assuming ESA continues with its plans to develop an automomous Columbus space station, when would you expect ESA to "Europeanize" the French manner spaceplane, Hermes?

Answer. In testimony to the House Subcommittee on Space Science and Applications on March 7, ESA's Director General stated that:

"Europe has expressed an interest in the studies undertaken by France on the Hermes spaceplane. Although this project is not for the time being an approved ESA programme, we will initiate studies together with the French authorities with a view reaching a conclusion at the latest, by 1987/88."

Question. To what extent would you expect Hermes to participate in the U.S. space station program?

Answer. The role of Hermes within the space station program is a matter still to be studied in depth. However, as mentioned in response to a previous question, logistics support and crew change-out are two functions that immediately suggest themselves.

Senator GORTON. We will now hear from Dr. Banks of Stanford University and Mr. Cohen of NASA in Houston.

With respect to each of you, your full written statement will be included in the record as if read. Given the time, we would appreciate a summary at this point.

Dr. Banks.

STATEMENTS OF DR. PETER M. BANKS, START LABORATORY, STANFORD UNIVERSITY; AND AARON COHEN, CODE AE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. **Banks**. Thank you, Mr. Chairman. I will abbreviate my comments. I think you have the written form before you.

The Task Force on Scientific Uses of Space Station is a NASA advisory committee. It is independent of many aspects of NASA and yet symbiotic in the sense that we require information from them to form our scientific opinion. And I think that you would find at a given time, that we represent a broad spectrum of the U.S. scientific community.

In addition, we have the participation of European, Japanese, Indian, and other foreign observers working with us. I also would like to add that we have had tremendous support from both Mr. Edelson and Mr. Culbertson in our activities. We have had four separate meetings and a summer study at Stanford University last year, and many of the points that I will raise today derive from that summer study.

There are three general topics that I would like to cover here. Our deliberations have been very extensive with respect to space station facilities, science operations, and how we go about preparing for the space station era. And I think you would agree these are all-important. They cover different aspects of the space station itself.

We have spent considerable effort evaluating the proposal for facilities for the space station. The most striking discrepancy that we have found between the original NASA description of the space station and the express needs of the space research community lies in the coorbiting platform, something that was mentioned earlier today.

As initially conceived, this element would be a multiuser facility with design features reflecting the advanced technology of the space station. We have worried considerably about this, and after considerable discussion within the task force, we have concluded that at least in the IOC period, there is no compelling need for this platform for the needs of the research community.

The needs of the research community would be far better met by the introduction of smaller coorbital free-flying modular satellites designed to make use of various space station resources, and this might include large bandwidths communications, repair and maintenance capabilities, and so forth.

In contrast, the space station polar platform has received enthusiastic support from a number of disciplines. In fact, I think it is fair to say that the polar platform is already over-subscribed with potential users.

The vista offered by polar platform is attractive to those connected with land, sea, and air observations, in addition to scientists concerned with different physical processes which link the sun and the earth. It is becoming clear that polar orbits serve many different purposes, that it might be even wise now to consider the installation of several space station related polar platforms.

I think you may have detected a flavor of that in Mr. Culbertson's remarks earlier today. We look to the contractor definition phase, basically to help resolve this question.

With respect to the core manned facility, we do have some special feelings and in particular, after a great deal of deliberation, it is the feeling of my task force that there should be at least six persons dedicated to the scientific uses of the station, and that this would lead to an IOC initial crew of eight persons, and we have communicated this to the space station project office at Johnson Space Center and to Mr. Culbertson.

One crucial issue that remains to be settled concerns the way that scientific users can communicate with space station experiments and support personnel. And I think you will find this perhaps personally interesting. In the past, we had relatively primitive modes of communication with respect to instruments in space and the ultimate scientific users. In fact, even today, we find that piles of magnetic tape accumulate in our laboratories as the primary output from activities in space.

The task force feels strongly that it is time to move forward to new modes of interaction which are consistent with capabilities now available through telecommunications technology. In fact, we have derived a new term called telescience which has been coined to describe the desires of the user community. Telescience implies a close synergistic connection can be established in real time between science investigators at their home bases to space-based human resources and the various experimental apparatus.

With such a tight linkage with voice, video, computer, and general data communications, it is possible to do research experiments in a much more productive way than in the past, giving opportunity to identify and explore unexpected effects, and to take advantage of the remote guidance of the principal investigators located in their home institutions.

While this concept is new, the implications are sufficiently important to think that its effective introduction into space station planning might be one of the major accomplishments of this facility.

I will turn now to science operations. We have been working very closely with the Office of Space Science and Applications to develop a reasonable set of space station science missions. These will enable the space station designers to include sufficient resources in the systems to avoid any serious problems in accommodating the science experiments. This has been a most important aspect of our activity.

I must say that the task force has been concerned from the very start about the ability of NASA to cover the cost of new experiments on the space station without distorting the ongoing program of space research unconnected with the space station. We are still concerned about this. The costs of research will be substantial and effective utilization of the space station by science and application users will be governed by the funds available, not by the number of creative and important science uses of the facility.

With such a situation, there is a real danger of harmimg various elements of the total OSSA program of research through diversion of funds to the space station. The bottom line on this isssue is that significant new funds should to be made available to OSSA for the conduct of its space station research. The funds now available are already spread very thinly.

The task force has also urged NASA to conduct more in-depth studies of the way science operations would be done on the space station. Telescience is one aspect of this, but much more needs to be done to understand the complete flow of experiments and experimental activities as they originate in the laboratory, on the ground, are built, tested, integrated into the space shuttle, flown into orbit, and operated in the space station environnent.

Unless NASA devotes significant effort to this activity in the near future, there is a real prospect of serious difficulties later in the program.

I will turn now to the third topic, which is preparations for the space station era. As a preface to this, I should say that the committee has regarded the space station not as a singular event to occur 7 or 8 or 9 years from now, but as a continuous development involving manned space adventures with the space shuttle leading into the space station.

We regard space station as part of the quickening pace of space research activity which utilizes human resource. From this perspective, space shuttle is an important precursor to the space station, and there are many things which can be done between now and IOC to ensure the best possible use of the space station.

For example, the task force has urged NASA to increase support for its spacelab and shuttle payloads program to provide a better basis of experiments for the conduct of human-assisted research in space. Many aspects of the conduct of science operations aboard the space station are uncertain and the practical knowledge gained from work with experiments on the space shuttle will be of great value in planning for the future.

The task force is also concerned about the progress of scientific activities associated with the space shuttle and the implications this has for space station research operations. Due to a lack of funds and paucity of flight opportunities, these activities are severely constrained and do not meet the current programmatic needs of the various research disciplines.

There have been significant delays in the scheduled flights of future programs and the funds available to progress at an adequate pace toward space station are lacking. Part of the difficulty seems to arise from competition for flights between commercial payloads, obligations to the Department of Defense, and the NASA-funded research programs. When perturbations rise in the STS system, replanning often gives priority to the commercial and defense payloads, resulting in serious impacts to the scientific missions.

Another factor related to the space shuttle science missions relates to the availability of adequate funding for postflight data analysis. More than ever before, the complexity and data-gathering intensity of these activities is responsible for greatly increasing the cost of scientific analysis. Many investigators in spacelab–1, for example, are nearing the end of their data analysis periods and finding little hope for further funding to continue their research.

I suspect the situation will become increasingly difficult as the backlog of shuttle payload mission data grows and that NASA will need to considerably enhance its funding of data acquired in these programs. When space station arrives, it will be essential to have a better understanding of the way long duration experiments should be funded for maximal scientific productivity.

Finally, an important factor in gaining experience prior to space station IOC lies in the opportunity to extend the on-orbit period of current spacelab flights. The task force has learned in recent months of several very inexpensive, means for doing this, and actively supports the concept of the inexpensive, longer duration orbiter. Extensions of 5 to 7 days, for example, would have a dramatic impact upon the scientific productivity of the space shuttle.

The importance of the space shuttle to the Space Station Program is strongly emphasized by the intense interest of the scientific community in the polar platform elements. To service this part of space station, it will be necessary to rely upon the space shuttle and the services expected to be necessary will consume precious on-orbit time. Consequently, the task force feels that a longer duration orbiter would have special benefit to the Space Station Program even after the IOC.

There are many other things I might add to this. My brevity isn't readily apparent, I assume, from your point of view, but I would be pleased to submit the formal transcript here as my testimony. And in addition, I note that the executive summary of our summer study report is missing from the material I sent to you, and I would like to supply that for the record.

Thank you very much, and I am pleased to answer any questions.

[The summary refund to follows:]

1. Executive Summary

GENERAL BACKGROUND

The Task Force on Scientific Uses of Space Station (TFSUSS) is organized under the NASA Advisory Council as a sub-group of the Space and Earth Science Advisory Committee (SESAC). The responsibilities of the Task Force include, among others, providing NASA with assistance in planning for the scientific utility of Space Station, helping NASA to define the relationship between Space Station and the existing program of space research, and acting as a focal point for the general interests of the national research community in developments relating to Space Station.

This report presents the results of a TFSUSS-sponsored Space Station Summer Study held August 13-17, 1984 at Stanford University. The Summer Study brought together members of the TFSUSS, an invited group of research experts from the U.S. and abroad, and representatives of NASA. The agenda of the study called for examination of a broad range of topics to identify critical issues relating to the Space Station development and operations. The considered opinions of the Summer Study are collected in this report. It gives both the general conclusions of the Summer Study and provides specific recommendations to NASA. Abbreviated discussions of the recommendations and conclusions are given in the following sections of the Executive Summary. In-depth discussions with more detailed background information are presented in the main body of the report.

RECOMMENDATIONS OF THE SUMMER STUDY

The following statements reflect the principal recommendations of the Summer Study. Reference to the specific chapter and section of the main body of the report is given at the end of each entry.

Preparations for the Space Station Era

NASA should provide a program plan detailing development of its overall space research activity including the Space Station as an integral element in that activity.

Such a plan should cover the time leading to and during IOC, and it should address at the least the following issues: Elimination of costly delays/slips in science payload missions both on the STS and on the Station; Implementation of hardware and software to optimize the servicing and maintenance capabilities provided by the Station; Balance of research opportunities between non-Station and station-related payloads; Mechanisms to insure adequate and continuing input to these programs from the general space research community. [§ 6.2].

We suggest that NASA request studies from its internal advisory committees with respect to understanding the relative roles of various space flight vehicles in their program plans of space research. [§ 6.2].

The Office of Space Science and Applications should re-evaluate its plans for utilization of the Space Shuttle to ensure adequate preparations have been made for IOC Space Station missions. [§ 6.2].

The Office of Space Station and the Office of Manned Space Flight should work jointly with the Office of Space Science and Applications to develop test-bed activities leading to the development of advanced communications and information systems appropriate to the needs of the scientific users of Space Station. [§ 6.2].

Activities Pertaining to the Space Shuttle

We recommend that NASA explore low cost options leading to the rapid development of an Extended Duration Orbiter. [§ 6.3].

NASA should develop an integrated plan for using the Space Shuttle as a test-bed for the advanced end-to-end communications and information system to be developed for the Space Station for the improvement of scientific operations in space. [§ 6.3].

Long term planning within the Office of Space Science and Applications should specifically identify possible Space Shuttle science missions in the post-IOC period. [§ 6.2].

Space Station Research Programs

Priority within the Space Station science program must be given to development of those research activities which are either fundamentally enabled or significantly enhanced by the capabilities of the facility or its orbiting adjuncts. [§ 6.1].

Plans for Space Station Activities

NASA should pursue studies leading to the development of adequate models of local and remote Space Station science operations for the various science and applications users. These models should identify longterm discipline goals with respect to remote operations without undue concern for the current limitations of technology. [§ 6.4].

External Working Groups

Broadly-based working groups should be established at each NASA field center with the aim of providing cooperative interaction with respect to the operations, management, and future development plans for Space Station. [§ 6.5].

Financial Planning

We recommend that the prospective budgets for Space Station and other research activities be developed and presented to the appropriate discipline advisory committees for their comments and advice. [§ 6.6].

Space Station Operation

NASA should undertake studies of the possibility of establishing the Space Station as a national facility with a support organization based upon experiences gained from the operation of large, multi-user, ground-based facilities. [§ 6.5].

Space Station Facilities

Based on the apparent lack of interest in the scientific disciplines towards use of a large, multi-user, co-orbital platform, the Summer Study participants recommend that NASA re-direct its efforts to provide realistic evaluation of alternative options for co-orbital, free-flying instrument carriers which meet the requirements of disciplines which will need such remote facilities at Space Station IOC. [§ 6.1].

We recommend that NASA devote special attention during its contractor study period to the possible development of standardized, modular platforms which can be easily configured to meet user needs of polar (and co-orbital) research activities. [§ 6.1].

Planning efforts should be undertaken by NASA and its supporting advisory groups to better define the possible missions which can use the attached payload facilities. Identification must be made of general use, permanently attached "core" investigative equipment which can be used to support a variety of externally oriented experiments. [§ 6.1].

NASA should undertake studies to define the needs of various research disciplines with respect to telescience activities and their relationship to the presence of space-based scientists and technicians. Evaluation should be made of needs for different forms of advance communications, local and remote knowledge-based information systems, and other activities related to improving the state of the art with respect to adaptive experiments. [§ 6.1].

NASA should conduct a detailed analysis to ascertain and characterize the specific needs for and requirements from a Space Station capability to service and repair free-flyers in a wide range of orbits, as well as to assemble large structures in space. Such an analysis should include the possibility of including a dedicated repair and service module in the core configuration. [§ 5.3].

We recommend that NASA request its contractors to study the concept and implications of establishing a technical equipment storeroom aboard Space Station to support a broad range of scientific research activity. [§ 6.1].

Delays in Space IOC

Discipline plans for utilization of Space Station should provide explicit alternatives which avoid undue stress to research programs in the event that IOC is substantially delayed. Such plans should be thoroughly discussed in advance with the appropriate discipline advisory committees. [§ 6.2].

International Participation

The participation of the international space research community in Space Station planning and eventual operations is of great importance and must be pursued with dedication and sensitivity by NASA. [§ 6.7].

CONCLUSIONS OF THE SUMMER STUDY

The following general conclusions were reached by the Summer Study group:

There is a concensus among the TFSUSS that the Space Station can be of great value to the advancement of space research. [§ 6.1].

All science disciplines currently supported by OSSA will benefit from the payload maintenance and repair capabilities provided by the Space Station. [§ 5.3].

The Summer Study participants agree that the human resources associated with the Space Station will play an important part in the development of space research activities in the future, and that the presence of a technical crew to work alone and in collaboration with ground-based researchers will enable a variety of new space research activities. [§ 6.1].

It is essential that NASA continue to encourage active participation of the national and international space research communities in the development and evaluation of its plans for Space Station. [§ 6.7].

CLOSING COMMENTS

Many more specific, scientific discipline-oriented recommendations and conclusions are given in the main body of the Summer Study report in subsequent chapters. As with any report, many positive events have occurred since the Summer Study, and a number of the recommendations contained here have already been adopted by NASA. It is readily apparent that the Space Station concept opens the way to a new future for NASA and the space research community of the world. Properly planned and executed, the Space Station and its subsequent family of associated activities will be seen in the future as a unique step of pivotal importance to the development of mankind's ability to understand and cope with the environment of space and the solar system.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. Why are smaller co-orbiting, free-flying satellites better suited for the conduct of space station science than one larger co-orbiting platform?

What is the likely cost differential between the two approaches?

On what grounds has NASA justified the single platform approach and opposed the multiple platform approach?

Answer. Smaller, co-orbiting satellites provide the opportunity to specialize resources and optimizing performance for the needs of particular experiments. Experience with the Space Shuttle has shown that multi-instrument platforms have serious problems with scheduling of activities, data acquisition, contamination, mechanical operations, and so forth. In addition, the integration of large experiments onto a platform is a complex task, and the resources required to carry out such activities for a number of instruments will inevitably lead to substantial loss of observing time.

The introduction of new classes of modular satellites would help alleviate these difficulties, and permit a more natural scheduling of flight activities.

I believe that the use of these smaller vehicles will provide a real gain in cost-effectiveness. But, to do so will require a serious effort on the part of NASA to identify common needs and technologies which can be applied to the problem of creating modular units which can be readily adapted to the needs of the users.

The concept of a single platform came from an initial analysis of potential scientific experiments contained in a larger data base. Discussions with the scientific community, however, have revealed that there are no disciplines which would support a large multi-instrument platform in low inclination orbit at IOC.

Question. According to your testimony, there is enthusiastic support for a polar platform as part of the space station infrastructure, enough support to possibly warrant several space station-related polar platforms.

What factors will drive the decision to deploy a second polar platform in the IOC?

Answer. There are several important factors which drive the need for multiple instrument platforms in polar orbits. They include:

1. The needs of certain disciplines for simultaneous observations of solar and terrestorial phenomena.
2. The requirements of NOAA for operational remote sensing instruments.
3. Conflicts in requirements for orbits to optimize viewing geometry for the different remote sensing applications.
4. Costs, which will undoubtedly be the most important factor affecting the decision to establish a second polar platform.

Question. A report submitted by NASA to Congress in November says that modifications to an Orbiter to extend its on-orbit duration to three weeks would cost close to $200 million, would result in reductions in the orbiter's capability, and would require a development period of 2½ to 3 years.

In light of these conclusions, do you still think that it is justifiable to develop an extended duration orbiter solely for the purposes you have mentioned?

Answer. The Task Force is aware of alternative plans and demonstrated capabilities which could substantially lengthen the on-orbit time of the Space Shuttle at a cost much less than $200 million. We strongly support the exploration of these lower cost alternatives. There is reluctance to do so within NASA on the basis that such a capability would weaken the argument for Space Station. This, we believe is not correct: An Orbiter with a 14 to 21 day endurance is simply not competitive with Space Station in terms of its resources or capabilities.

In addition to simply enhancing the scientific productivity of Space Shuttle missions (perhaps by as much as a factor of two!) we also believe that a longer on-orbit duration will be essential for adequately servicing the polar platform elements of Space Station. A longer duration Orbiter would also prove valuable for the initial construction of the station itself especially if extensive EVA is required for initial assembly.

Question. You have mentioned that a crew size smaller than 8 could lead to serious difficulties in the conduct of on-orbit research and other operations.

Could you describe for us some of these difficulties?

Has NASA agreed with your crew size requirement, and, if not, why?

Answer. Experience with Space Shuttle has shown that the conduct of scientific experiments is difficult with fewer than two persons. In addition, preparation of experiments, the expectations of "on-the-job" training, and general operating procedures will require a third technical person to be present in a support role each shift. Since 12 hour shifts appear to be feasible, we arrive at a requirement for six technically trained persons to be present as part of the science complement of the facility. NASA estimates that two additional persons will be required to operate the Space Station IOC, yielding our number of 8 total persons at IOC.

NASA has asked its study contractors to study the impact of various crew sizes, including our suggested number of 8.

Question. According to your statement, a possible lack of sufficient power and the presence of large microgravity forces could impose crucial limitations on the microgravity science experiments.

What is the nature of these potential problems, and are you confident that they will be resolved?

Answer. Furnaces and other equipment needed for materials processing have large power requirements.

There is evidence that very small forces can seriously affect the crystallization of certain materials. There is a desire to minimize this effect by designing the facilities to avoid random forces and the effects of residual gravity. At some point there will be a need to assess the cost trades implicit with this situation.

Question. According to your testimony, unless NASA devotes significant effort to studying how science operations will be conducted on the space station, serious difficulties could result later in the program.

Answer. At the present time we have no clear idea of the full range of support requirements associated with different scientific uses of Space Station. We have suggested that NASA take a close look at some of the prospective missions, and attempt to quantify the user requirements. Such studies have been done extensively for general operations of the overall Station, but not for specific scientific projects. We expect that such studies would help set user requirements for communications, on-board analysis facilities, post-flight data analysis, etc.

Question. In the recommendations of your summer study, you have suggested that NASA's internal advisory committees study the relative roles of various space flight vehicles in their program plans of space research.

What are the space flight vehicles you are referring to, and what are your concerns relative to your recommendations?

Answer. It is important to examine the roles of ground-based observations, aircraft, rockets, balloons, free-flying satellites, the Space Shuttle, and the Space Station from the point of view of function and cost within the different scientific disciplines. Emphasis on just one element, such as the Space Station, can lead to difficulties in the overall program of space research. We feel that each discipline would benefit from a reassessment of its flight platform needs.

Question. The recommendations of your summer study state that NASA's Office of Space Science and Applications should re-evaluate its plans for utilization of the Space Shuttle to ensure adequate preparations have been made for IOC Space Station missions.

What are your Committee's concerns relative to this recommendation?

Answer. We are very concerned about the progress of the Spacelab and Shuttle payloads program. The experimental program has a history of high cost, substantial delays and other difficulties which affect scientific productivity. Such difficulties must be overcome if Space Station is to be successful. And, we note, access to Space Station will be via Space Shuttle, imply a possible compounding of flight complexity.

We advocate using the Space Shuttle as a testbed for gaining experience on manned scientific experiments: Results from an enhanced program would have a strong, positive impact upon plans to use Space Station.

QUESTIONS OF SENATOR HOLLINGS AND THE ANSWERS

Question. Based on your experience with NASA and with the Task Force on the Scientific Uses of Space Station, are you confident that the space station will benefit science?

How will the recommendations of your Task Force and those of the Space Science Board of the National Academy of Sciences be incorporated into NASA's definition, design and development of the space station architecture?

Answer. The value of Space Station for the pursuit of research activities in space will be determined by the interaction of many different factors. These include:

1. The extent to which the facilities and services meet the evolving needs of the scientific users,
2. Provision for adequate funding of Space Station research projects,
3. Support for broad programs of research which reflect national space research priorities determined by committees of the National Academy of Science and the NASA Advisory Council system,
4. Selection of research projects on the basis of excellence and suitability for the facilities and resources offered by Space Station,
5. Development of internal research management plans which assure the space research community of continuity of flight opportunities,

6. The availability of sufficient funds for supporting ground-based research and analysis tasks,

7. Continued support for non-Space Station projects and missions.

It is crucially important that the addition of Space Station be done without damage to existing and planned non-Space Station related program of space research, either through diversion of funds or institutional bias towards the Space Station program.

At the present time, individuals responsible for the development of plans for Space Station have given strong support to the needs of the research users, and the Task Force is convinced that many benefits will accrue to science as a consequence. However, plans to exploit the resources of Space Station call for substantial expenditures, and the Task Force is concerned that budgetary constraints such as those in force this year may result in lessened support for science activities which are not directly connected to Space Station. The failure to initiate any new scientific satellite research programs in the FY-86 budget, for example, is seen as a serious matter by the space research community: How would a similar period of budget constraint affect NASA research plans when Space Station is an active part of the Office of Space Science and Applications program?

As a consequence of thoughts such as these, The Task Force feels it is essential for NASA to maintain a balance of activities between its various programs to insure the health of space science as a whole, not just those parts that relate to Space Station.

With respect to the influence of the Task Force, our recommendations are communicated in a formal manner to the NASA Advisory Council and to individuals within NASA having responsibility for the development of Space Station and its program of research activities. The persons most frequently contacted include the Associate Administrator for Space Science and Applications, the Associate Administrator for Space Station, and senior members of their staffs. In addition, the Task Force has worked closely with members of the Space Station Project Office at Johnson Space Center, and with other members of Space Station support projects at other NASA Centers. Through these contacts, the Task Force attempts to provide designers of Space Station with an active appreciation of the needs of the prospective Space Station science and applications user community. We have no guarantee that our recommendations will result in any specific actions with respect to the Space Station definition or subsequent developments related to the management of the facilities.

Question. In a recent article of Science magazine, NASA's chief scientist, Frank McDonald, makes three very interesting statements that the Committee would like your opinion on.

First, viewed from present experience there are three broad categories for scientific use of the space station: (1) an in-orbit assembly, refurbishment and repair facility; (2) a laboratory; and (3) as a base for other missions.

Do you agree with this representation? Or are the optimal uses of the space station for scientific purposes more limited?

Second, that the "responsibility for designing and building a scientifically useful space station is a mutual one "shared by NASA and the scientific community jointly."

Do you agree with the statement? And are you confident that NASA will be able—technically and financially—to incorporate the recommendation of the science community?

Third, concurrent with developing the space station architecture, NASA should enhance the level of science done with the space shuttle during the remainder of this decade.

Do you agree or disagree with this statement: Are you satisfied with NASA's efforts to optimize the use of the space shuttle? What additional recommendations would you make to enhance the shuttle's role in space science and as a pre-space station test environment?

Answer. Dr. McDonald has participated in many of the activities of the Task Force, and has contributed many important insights concerning Space Station and its future role within the overall program of NASA-sponsored space research. We value him as a member in long standing of the space research community.

The Frost and McDonald paper in *Science* magazine give an overview of the value of Space Station and attempts to answer questions both about the financial impact of Space Station upon NASA science and applications funding, and the types of scientific projects which might be undertaken with the new facilities.

The three broad categories of scientific use listed in the first part of this question reflect the general conclusions of the Task Force. However, it is necessary to understand that the term "laboratory", is a very inclusive concept, encompassing both the activities planned within the Space Station modules as well as experiments flying on attached payload facilities, local (co-orbital) platforms and free-flyers, and the more remove polar platforms. This broader interpretation was missing from the Frost and McDonald article. Overall, their article emphasized NASA plans for large observations to be operated in concert with Space Station. A more balanced presentation would include discussion of the wealth of science objectives planned for the internal laboratories, especially with respect to life sciences and microgravity sciences and applications.

With respect to in-orbit assembly, refurbishment, and repair (ARA), it seems clear that there is special value to such activity. However, ARA is only a means for providing better technical support to scientific projects: In itself ARA cannot generate new science products. The Task Force, while endorsing the ARA concept, feels that it must give strong, primary emphasis to the direct benefits offered by new scientific projects enabled by Space Station in its role as a new facility with extended elements for the conduct of experiments and observations not heretofore possible with smaller, unmanned spacecraft.

With respect to the second point concerning responsibility shared between NASA and the scientific community, it is essential for the prospective users of the facilities to make known their ideas and needs to the system planners and operating managers. However, the record of past indicates that once plans have been formulated by NASA, they will regard it as their responsibility to develop, test and operate Space Station within a framework of needs and resources which may, at times run counter to the desires of the research community. Consequently, it is important for the scientific community to work continually with NASA field center personnel to convince them of the legitimate role of "customers" in determining the types and extent of services to be provided. This includes selection of the hardware to be put in orbit, attention to user needs in developing operations models, inclusion of new telecommunications modes to improve ground and space interactions, and plans for future growth.

Along these lines, the Task Force has suggested to NASA that it should investigate the way national laboratories are operated for selected research communities. Such facilities have a close liaison with their users, and plans for experiments, new equipment, and future directions are developed jointly with the user community. Such a national laboratory model may be appropriate for Space Station.

The single, most difficult aspect of progress towards Space Station will be the conflict between the desire of project engineers to design a complete system immediately, and the need of the scientific user community to rationalize their longterm plans for activities in space. The different time scales of these two groups can open the way to technical decisions being made arbitrarily on the basis of incomplete understanding of the needs of the science and applications programs. One of the important tasks of the Task Force has been to try to communicate general needs of the research users and to encourage NASA planners to avoid premature technical decisions which may, in the future, not be the best for the customers.

The third point, concerning the increased use of the Space Shuttle for scientific purposes during the pre-IOC period, is of great importance. The Spacelab and the Shuttle Payloads program is an important bellweather for Space Station, and enhanced use of the Shuttle for scientific purposes will be an important path to Space Station. Several points can be made:

1. The Space Shuttle provides an opportunity for gaining experience in the conduct of man-assisted research in space. There are a variety of problems relating to experiment development, science operations, and environmental factors which need to be thoroughly understood before undertaking the much more strenuous activities associated with Space Station.

2. NASA must explore the programmatic and managerial aspects of expensive, manned scientific missions within the context of its programs which, heretofore, have been directed towards unmanned satellites. The transition to the Space Shuttle has not been easy, either with respect to the funding of projets, not the ease of scheduling of scientific missions. With Space Station arriving in less than a decade, it is essential for these problems to be solved, and an enhanced program of Space Shuttle science activities is an effective way of developing the expertise and expertise required.

3. It is also necessary to emphasize the long-term importance of Space Shuttle to space research. Even with the introduction of Space Station and its local and remote elements there will be a need for shuttle science missions. Such missions will be used to investigate regions of space inaccessible to Space Station, to provide short term tests of new types of instrumentation, and to give rapid turn-around for ex-

periments where materials must be rapidly returned to earth. In addition, support of the polar elements of the Space Station program represents a permanent extension of the Space Shuttle science program; i.e., polar flights will be necessary to provide technical service to the polar platforms. This work will undoubtedly involve a variety of related scientific activities. To carry out this task responsibly, it is essential that continual improvements be made in Shuttle capabilities and science operations.

Question. In your testimony you indicate that the science community has no perceived need of a "co-orbiting platform" in the IOC and there are perceived limitations facing microgravity science experiments.

In your opinion, should the space station IOC only consist of multi-purpose elements or should there be room for dedicated elements? For example, a co-orbiting platform dedicated to commercial endeavors?

Can the space station IOC architecture respond to the various needs of the various users, or will there be "winners" and "losers" because of various constraints—technical and budgetary?

Should a greater effort be made to let the private sector finance and develop elements of the IOC?

Could the Space Station IOC accommodate 3 microgravity research modules, or would Electro-Politics preclude such a high degree of "duplicity"?

Answer. The Task Force is charged with evaluating the needs of its constituent scientific disciplines. The co-orbit platform offers the possibility of extensive centralized resources at the price of considerable mutual interference between experiments, scheduling conflicts, and different times for instrument development. Members of the Task Force, based on their experiences, believe that it would be wise to focus attention at IOC upon smaller spacecraft which can be tailored to meet the needs of individual experiments or missions. We have suggested that Spartan-class satellites having modular resources as well as capabilities for on-orbit assembly, repair, and refurbishment would be more important to the pursuit of scientific activities at IOC than a single, large, co-orbital platform.

The Task Force has met some resistance to this idea, based largely on the possibility of another class of hypothetical user who might need special facilities separated from the core station. It may well be, for example, that some microgravity experiments might be done on such a platform. Or that there could be commercial uses for such a facility. However, for the IOC period, and for the scientific needs seen by the Task Force, it appears that the interests of scientific research would better be met at IOC by the development and use of new satellites having modular resource capabilities, and which are sufficiently flexible in design to meet the needs of diverse scientific missions.

With respect to "winners" and "losers", it is inevitable realities will result in selection of particular facilities and resources. The reality of the situation is that the current OSSA budgets are already stretched thinly over many scientific projects, and the further pressures of Space Station research funding will almost certainly change the course of NASA's research programs. Thus, it is essential that the equipment and supporting facilities be chosen with great care and with the broad needs of the scientific user community in mind.

The aims of commercial activities in space could be best aided through the development of low-cost access to space. Private financing of certain elements of Space Stations is unwise unless there is a better understanding of the boundaries between the research goals of NASA and the commercial investigations of private enterprise.

Question. Mr. Culbertson in his testimony indicates that NASA's Office of Space Science and Applications has devised a list of "intended uses" of the space station for its program planning.

Does the OSSA list of "intended uses" reflect the recommendations of your Task Force? Does NASA have the financial capability to accommodate your proposal to provide significant new funds for the conduct of a space station research program?

Answer. One of the main activities of the Task Force has been to assist NASA's Office of Space Science and Applications (OSSA) in developing a list of possible missions for Space Station. In doing this the Task Force has considered both the established goals and priorities for space research, and our conviction that the costs of Space Station missions must be kept within the pocketbook of OSSA. To me personally, it seems that the research plans for Space Station are sufficiently large, in a cost sense, to have a strong impact on the funds available for non-Space Station programs. For this reason I advocate a rapid commitment of new funds within NASA to help meet the legitimate, new demands for adequate support of Space Station science and applications projects.

Question. As you are well aware, there is currently a long waiting list to gain access to the shuttle and to Spacelab.

In light of this fact, how can the space science community feel confident they will have any better access to the space station than the in-house NASA science and space applications work?

Answer. Access to space via the Space Shuttle is proving expensive, both in terms of actual project costs and the time required by research workers to acquire scientific data following inception of their programs. The current demands of mission definition, planning, testing, integration of instruments and waiting for a flight impose great burdens on NASA research funds and upon the scientific productivity of research participants. In addition, flight schedules for major missions have been unreliable and, when changes occur, extensive replanning has been necessary, all at substantial expense of time and funds. Thus, it is fair to say that the Task Force does worry about the eventual state of affairs with respect to scientific operations with Space Station.

Question. In an August 21, 1984 letter to Mr. Culbertson, you state, "there has been no study of science and applications user operations which would match that done at JSC with respect to overall operations. The lack of this definition of science operations was keenly felt with respect to the communication and information systems activities supporting users."

Has NASA done anything to remedy this situation? What recommendations do you have to improve this situation?

Answer. NASA is aware of the problem, and initial studies of the problems associated with Space Station science operations will be undertaken at several NASA field centers in the next few months.

Question. You have been referenced in several trade press articles as stating that the proposed manned space station could cost $18 to $19 billion, not including operational costs.

Is this portrayal accurate? Do you still feel the unmanned station will cost this much? What are the principal differences between your estimate and the NASA estimate?

Answer. My estimate was based on figures which included inflation, the value of potential contributions from other countries, Space Shuttle launch costs to construct the IOC station, and other expenses associated with operations, all over the first several years. Until the final design has been adopted, and all elements of the overall budget are set, all such estimates are simply speculation. If Congress insists that NASA stay within a certain cost figure, I believe that a certain configuration will be found which meets his limit.

I am much more concerned that adequate funds be allocated to cover the costs of new scientific activities associated with Space Station. My estimate of this is that approximately $200 million per year of new funds are required to sustain the present OSSA scientific program and to meet the added activities of Space Station. The determination of an accurate add-on cost is essential if we are not to meet a funding crisis in space science in the early 1990's.

Question. The Subcommittee has been informed that the science community would like the space station to have a "clean" engine, not a hydrazine engine.

Would you please discuss the advantages of a "clean" engine? what effect would the development of a "clean" engine have on the overall performance and cost of the space station?

Answer. This question hasn't been discussed within the Task Force, and I have no special information to contribute at this point. Contamination of instruments is obviously an issue, and studies of this should be undertaken by NASA and its contractors.

Senator GORTON. That will be included in the record.

Mr. Cohen.

Mr. COHEN. Mr. Chairman and members of the committee, it is a pleasure for me to be here today to provide you a status of the Advanced Technology Advisory Committee's report on automation and robotics for the space station.

We have talked about these terms somewhat and I would like to define these terms that I am talking about. Automation is the technology by which control of the physical process or devices can be exercised according to preestablished rules, normally without human intervention. And robotics is the technology of devices, sensors, computers for carrying out under human or automatic control, physical tasks that would otherwise require human ability.

An important stimulus to focus the agency's attention on automation and robotics has been provided by Congress in its mandate to study the advancement of state of the art of the automation and robotics with the space station and U.S. economy. The public law that provides this states that the Administrator shall establish an advanced technology advisory committee in conjunction with NASA's Space Station Program and that the committee shall prepare a report by April 1, which has been done, identifying specific space station systems which advance automation and robotic technologies not used in existing spacecraft.

In order to accomplish this, there were three subtasks that put this report together: the Advanced Technology Advisory Committee which I chaired, the automation and robotics panel administered by Cal Space, and Aerospace Contractor studies. The method of putting this report together was an open process, and the Advanced Technology Advisory Committee's report used the information from the Cal Space report and the Aerospace Contractors a great deal in putting our report together. A summary of the preliminary recommendations of the Advanced Technology Advisory Committee's report are as follows:

Automation and robotics should be a significant element in the Space Station Program. The initial space station should be designed to accommodate future evolutionary growth in automation and robotics, and that is probably one of the most significant recommendations because that allows the transparency to take care of the advancements in the state of the art for the space station in an evolutionary concept. So that is probably the most significant recommendation.

The initial space station will utilize significant elements of automation and robotics technology. The criteria for the incorporation of automation and robotics technology should be developed and promulgated. Verification of performance of automated and robotic systems should be stressed, including terrestrial and space demonstrations to validate technology for space station use.

Use should be made of technology developed by industry and Government. The techniques of automation should be used to enhance NASA's management capability. NASA should provide the measures and assessments to verify the inclusion of automation and robotics into the Space Station Program for space activities. We believe the benefits of advanced machine intelligence, robotics, and automation will be increased productivity, increased responsiveness to innovation, lower cost of operations, improved reliability, greater autonomy, the ability to perform tasks unsuited to humans alone, and a reduced exposure of humans to hazardous situations.

Benefits will also accrue to the U.S. economy because the space station will be more suitable for commercial ventures with flexible and reliable systems and optimum use of crew time. The advances in automation robotics stimulated by space ventures can be applied in terrestrial situations and in settings ranging from the factory floor to the bottom of the sea to the homebound elderly.

The initial space station will have a need for more automation than has been previously flown on spacecraft. My committee feels it is very feasible for systems such as the electrical power system, guidance, navigation and control, communication and tracking, information management system, environmental control life support, to have controllers that are enhanced by an expert system for trend analysis, fault diagnosis, statusing and scheduling.

We also feel that teleoperation, as you saw in the film with a dextrous type of end deffector will be needed in order to fabricate the space station and maintain the space station.

We also feel that voice control systems will be utilized in the initial space station.

That concludes my statement, sir.

[The statement follows:]

STATEMENT OF AARON COHEN, DIRECTOR, RESEARCH AND ENGINEERING, JOHNSON SPACE CENTER AND CHAIRMAN, SPACE STATION ADVANCED TECHNOLOGY ADVISORY COMMITTEE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Members of the Subcommittee:

It is a pleasure to appear before you today to discuss the activities of NASA's Space Station Advanced Technology Advisory Committee. This testimony will briefly review Advanced Technology Advisory Committee (ATAC) activities over the last year in preparation of the report to Congress on the potential for advancing automation and robotics technology for the Space Station and for the U.S. economy.

BACKGROUND AND INTRODUCTORY REMARKS

In April 1984, at the request of the House and Senate Committees on Appropriations, NASA initiated a study to evaluate alternative Space Station systems design concepts and systems technologies which would use advanced automation and robotics. To accomplish this automation study, NASA contracted with the California Space Institute to oversee an independent, non-aerospace industry/university team. Additionally, four aerospace contractors (GE, Hughes, Martin Marietta and TRW) were tasked with automation and robotics conceptual design studies of representative functions on the space station and Boeing contributed a fifth case study. Finally, SRI International was engaged to perform certain technology evaluation and forecasting, in general and in support of the case studies.

As part of the Conference Report (House Report 98-867) accompanying the FY 1985 HUD-Independent Agencies Appropriations Act (P.L. 98-371), the Conferees noted that the Space Station program offers an opportunity to stimulate the development of advanced technologies in the fields of automation and robotics. To that end, P.L. 98-371, dated July 18, 1984, provides that:

> "...the Administrator shall establish an Advanced Technology Advisory Committee in conjunction with NASA's Space Station program and the Committee shall prepare a report by April 1, 1985, identifying specific space station systems which advance automation and robotics technologies, not in use in existing spacecraft, and that the development of such systems shall be estimated to cost no less than 10 per centum of the total Space Station costs."

In their report the Conferees further noted that NASA should examine existing systems "whose potential for enhancing automation and robotics technologies appears promising," and that it was their expectation that such technologies might not only "increase the efficiency of the station itself" but also "enhance the Nation's scientific and technical base leading to more productive industries here on Earth."

As a result of its examination, the Advanced Technology Advisory Committee agrees that a key element of the "right" technology for the Space Station era is extensive use of advanced, general purpose automation, robotics, and artificial intelligence. This could include many systems and devices (such as computer vision, expert systems, and dextrous manipulators) that have been made possible by recent advances in artificial intelligence, robotics, computer science, and microelectronics. However, the experts in this technology tell us that while many of these systems are or will be available for the initial Space Station, other technologies, which would provide general purpose infrastructure support functions, characterized by greater flexibility, adaptability, autonomy and intelligence, will require substantial research and development investment in order to reach maturity for use in evolutionary Space Station.

The Advanced Technology Advisory Committee (ATAC) was constituted in the fall of 1984, and has drawn upon the work of the Automation and Robotics Panel, led by the California Space Institute. The California Space Institute study is being submitted with the ATAC report to the Congress. As a result of our examination directed by the Congress and our review of the Cal Space Panel and contractor efforts, and an assessment of the engineering implications of the user and customer mission requirements, the ATAC has come to believe that a great deal of advanced automation and robotics may be needed on an evolving Space Station complex to provide the kind of flexible, adaptable, multi-purpose facilities in space which will be most productive and supportive of the users, customers, and operators. The Space Station (and the manned space program in general) would have used a significant amount of automation and robotics, so in one sense we are dealing with how much more advanced, general purpose automation and robotics may be used. A great deal has already been achieved to integrate advanced automation and robotics planning into not only the NASA activities, but also those of the Space Station Phase B contractors through the requirements stated in the Request for Proposals.

I believe the ATAC report (consisting of two volumes) can guide NASA in implementing this advanced technology to meet the needs of the Space Station users with highly productive and low operating cost facilities. This will be important to the commercialization of space as well.

Following my appointment by the NASA Administrator as Chairman of the ATAC, I selected a group of distinguished members, not only because of their professional experience and capabilities, but also because the organizations they represent will be responsible for assuring a high level of automation and robotics accommodation aboard the initial Space Station and its associated platforms which NASA undertakes as a result of the recommendations of both the Cal Space and ATAC studies. This gives the best opportunity to sustain the enthusiasm and guide the activities at the working level.

A key element of the approach taken by ATAC from the outset was to be aggressive in identifying the best the technology has to offer as input to the Space Station definition and preliminary design process, but not to subvert or overly constrain the process or the managers prior to this very detailed activity.

Another objective was to involve industry, academia, and aerospace contrators in identifying specific Space Station systems which advance automation and robotics technologies through cooperation with, and integration of, the various automation/robotics tasks: the aerospace contractor case studies; the Cal Space Automation and Robotics Panel effort; and the Advanced Technology Advisory Committee (ATAC) study. The organizational methodology used for NASA's Space Station automation studies is depicted in Figure A. The Manager of the automation study is Mr. Dan Herman, NASA Headquarters Office of Space Station, and the Deputy Manager is Dr. Victor Anselmo, NASA Headquarters. Dr. Robert A. Frosch, Vice President of General Motors, served as Chairman of the Steering Committee. The California Space Institute of the University of California formed the Automation and Robotics Panel which consisted of representatives of industry, academia, and government.
The panel was divided into subpanels to prepare the various sections of the Cal Space report. The ATAC Committee has tried to listen very closely to this Panel's technical recommendations.

As part of the effort, several aerospace contractors studied automation and robotics in specific areas, as follows:

Boeing	Operator/System Interface
General Electric	Space Manufacturing Concepts
Hughes	Subsystems and Mission Ground Support
Martin-Marietta	Autonomous Systems and Assembly
TRW	Satellite Servicing

In addition, SRI International provided a technology assessment based on the contractors studies, their knowledge of technology, and the anticipated technology readiness.

Because of the very limited time available, the contractors were directed to identify "drivers," or factors, for advanced automation leading to the identification of representative systems or mission scenarios within their study area. They were asked to study the automation/robotics application for the evolutionary Space Station without cost or technology readiness constraints. It was not intended that the contractor studies address all aspects of automation and robotics applications to the Space Station program, but to address representative applications believed to be typical of those requiring advanced automation.

An ATAC Support Group was formed to assist these efforts.

They functioned as members of the Space Station Automation Study Team, observers at the Automation and Robotics Panel meetings, and as major participants in the support to ATAC. The ATAC support group assimilated the inputs from various contributors into the two-volume ATAC report. The Johnson Space Center Artificial Intelligence Office provided the initial draft of the report and integrated comments and revisions for the final version. Another eighteen NASA and JPL employees provided draft material. This further broadened the base of involvement in the Agency at the working level.

In addition to membership on ATAC and the ATAC Support Group, the Level B Space Station Program Office was involved through periodic briefings and copies of draft documents. All prime bidders for NASA's Space Station Phase B systems definition contracts were also provided draft documents in a timely manner so they were aware of our thinking.

The entire process for the Space Station Automation Study was open and iterative. In addition to the three iterative loops displayed in Figure A, there were many information interchanges. All meetings, presentation documentations, etc., were completely open and available to all participants. All substantive outputs of this effort were made available in a timely manner to all interested parties. This total effort required and received extraordinary cooperation from all participants.

The objectives of the ATAC examination are several:

- Identify potential advances in the state-of-the-art in automation and robotics technologies for use in the Space Station and to benefit the U.S. economy.
- Provide guidance for NASA Space Station program managers and prospective Space Station definition contractors to direct their efforts toward examination of the potential for advancing automation and robotics technologies though their incorporation in the overall development of the Space Station.
- Document, in a single convenient source, important considerations in automation and robotics, specifically:
  - --NASA Space Station engineering and programmatic aspects
  - --Recommendations of the academic and industrial community
  - --Descriptive and background material on the relevant technology
  - --Case studies of applicaions of advanced automation and robotics
  - --Technology projections and research recommendations

Documentation of the results, which are nearing completion, will be provided as follows:

- The Executive Overview, Volume I, which synopsizes the major findings of the study.
- The Technical Report, Volume II, which provides:
  - --Some general background to familiarize the reader with the technologies and potential of automation and robotics
  - --The Space Station design considerations of importance for automation and robotics
  - --The state of the technology and needed advances
  - --The guidance to be given to potential Space Station contractors so their efforts will result in a plan for advancing these technologies
  - --Considerations for technology transfer to U.S. industry and for space commercialization
- The companion document "Automation and Robotics for the National Space Program," by the Automation and Robotics Panel, led by the California Space Institute, which provides independent, corollary findings.

Related documentation of studies done by aerospace companies and by SRI International is referenced by SRI International is referenced and should be read in conjunction with the ATAC report.

PRELIMINARY RESULTS STILL UNDER REVIEW

For space activities, the ATAC believes the benefits of advanced machine intelligence, robotics, and automation could be:

- Increased productivity--with astronauts functioning as managers on behalf of station users rather than as operators carrying out routine functions.
- Increased responsiveness to innovation--with the automated Space Station being more flexible and adaptable.
- Lower cost of operations--with systems that can run at peak efficiency.
- Improved reliability--with improved detection, diagnosis, repair and recovery from abnormal situations.
- Greater autonomy--with improved monitoring and control of station systems and less reliance on ground support.
- The ability to perform tasks unsuited to humans alone--such as the assembly of large structures.
- A reduced exposure of humans to hazardous situations, such as extravehiculr activities, fueling tasks, and servicing satellites in very high (geosynchronous) orbits where radiation may be harmful.

Benefits could also accrue to the U.S. economy because:

- o The Space Station would be more suitable for commercial ventures with flexible and reliable systems and crew time for management action.
- o The advances in automation and robotics stimulated by space ventures could be applied in terrestrial situations in settings ranging from the factory floor, to the bottom of the sea, to the home-bound elderly.

The ATAC has identified guiding principles, which are intended to reflect the level and general areas to which advanced automation and robotics should be applied. Some are "baseline," in the sense that they should be followed loosely, independent of the actual level of funding made available for the Space Station effort. Others are meant to apply to an augmentation of the effort, should additional funds be made available along the lines indicated by the Automation and Robotics Panel. A summary of the preliminary "baseline" recommendations are as follows:

1. Automation and robotics (A & R) should be a significant element in the Space Station Program.
2. The Initial Space Station should be designed to accommodate future evolution and growth in A & R.
3. The Initial Space Station should utilize significant elements of A & R technology.
4. Criteria for the incorporation of A & R technology should be developed and promulgated.
5. Verification of the performance of automated and robotics systems should be stressed, including terrestrial and space demonstrations to validate technology for Space Station use.
6. Use should be made of technology developed for industry and Government.
7. The techniques of automation should be used to enhance NASA's management capability.
8. NASA should provide the measures and assessments to verify the inclusion of A & R in the Space Station Program.

Additional recommendations for an augmented effort are as follows:

9. The Initial Space Station should utilize as much automation and robotics technology as time and resources permit.
10. The evolutionary station should achieve, in stages, a very high level of advanced automation.
11. An aggressive program of long range technology advancement should be pursued recognizing areas NASA must lead, leverage, or exploit.
12. A vigorous program of technology transfer to U.S. industries and R & D communities should be pursued.
13. Satellites and their payloads accessible from the Space Station should be designed, as far as possible, to be serviced and repaired by robots.

NASA should use the Space Station "Definition and Preliminary Design" process (Phase B) to define the uses of automation and robotics to achieve increased human-machine productivity and the advances needed as the Space Station Program evolves. I understand that an implementation plan for assuring that Phase B will address automation and robotics needs adequately using a systems approach is being prepared by the Office of Space Station.

The potential for automation on the Space Station includes almost all systems and functions. There will be an evolutionary progression toward the goal of an autonomous Space Station. However, all initial designs should utilize as much mature automation as technologically feasible within cost constraints while not precluding eventual growth. Subsystems design should be targeted conceptually for the mature (year 2010) Space Station, and modifications should be made as necessary for the initial station, recognizing the readiness of the technology and the lead time required to achieve implementation.

Table A depicts some preliminary goals for advanced automation and robotics applications on the initial station.

TABLE A - IOC AUTOMATION & ROBOTICS APPLICATIONS GOALS

o ELECTRICAL POWER

Controllers Enhanced by Expert Systems for
--load distribution & switching
--solar array orientation
--trend analysis
--fault diagnosis

o GUIDANCE, NAVIGATION & CONTROL

Enhanced by Expert Systems for
--station atitude control
--experiment pointing
--orbital maintenance & reboost
--rendezvous navigation
--fault diagnosis

o COMMUNICATION & TRACKING

An Executive Enhanced by Expert Systems for
--communication scheduling
--rendezvous and docking
--data rate selection
--antenna pointing

o INFORMATION & DATA MANAGEMENT

An Executive Enhanced by Expert Systems Control of
--subsystem statusing
--trend analysis
--fault diagnosis expert system
--redundancy & configuration management
--data base management

o ENVIRONMENTAL CONTROL & LIFE SUPPORT

Knowledge-based Controllers for
--trend analysis
--fault diagnosis
--crew alarm
--station atmosphere monitor & control
--hypersonic chamber

- GENERAL
  - Teleoperation of Mobile Remote Manipulator with collision avoidance
  - Mobile multiple-arm robot with dextrous manipulators for EVA & IVA inspection/ORU exchange
  - Systems designed to be serviced, maintained, and repaired by robots
  - Primary Space Station control in space with appropriate backup

CONCLUSION

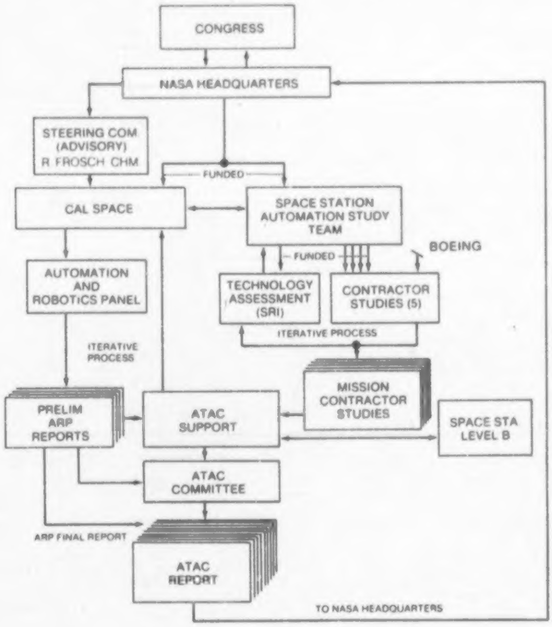
As you can see from the above activities, we are taking this subject quite seriously. ATAC feels an evolving Space Station could contain a high level of general-purpose automation and robotics. As a result of the Phase B activity, we will learn about the cost of the initial system, which could use this advanced automation and robotics, beyond what we would normally have employed.

We may find that using this advanced, general-purpose technology could increase initial costs, but significantly lower operating costs. However, those added funds might be wise investments to obtain a relatively large payoff when also taking account of potential for terrestrial applications. We are closely involved with the Space Station preliminary design process, so we will develop a good feel for uses, and systems and costs. Equally important, NASA should promote the transfer of the new technology to terrestrial situations where it will benefit the U.S. economy. These systems will provide the United States with important new methods of generating and exploiting space knowledge, and will thereby help preserve U.S. leadership in space.

We look forward to continuing to work with the Congress on advancing automation and robotics technologies.

Mr. Chairman, that concludes my prepared statement. I would be happy at this time to answer any questions that you or the Subcommittee might have.

Figure A — Methodology for the Space Station automation study


CONGRESS
NASA HEADQUARTERS
STEERING COM (ADVISORY) R FROSCH CHM
FUNDED
CAL SPACE
SPACE STATION AUTOMATION STUDY TEAM
FUNDED
BOEING
AUTOMATION AND ROBOTICS PANEL
TECHNOLOGY ASSESSMENT (SRI)
CONTRACTOR STUDIES (5)
ITERATIVE PROCESS
ITERATIVE PROCESS
MISSION CONTRACTOR STUDIES
PRELIM ARP REPORTS
ATAC SUPPORT
SPACE STA LEVEL B
ATAC COMMITTEE
ARP FINAL REPORT
ATAC REPORT
TO NASA HEADQUARTERS

Questions of Senator Gorton and the answers

Space Station

ATAC Recommendations

Question 1: Just what are the recommendations of your Committee to NASA, and how will they be implemented into the Phase B contracts and into the Space Station development? What would it cost to implement your recommendations? What practical considerations will dictate which of these recommendations will be implemented?

Answer 1: The recommendations are summarized in my written testimony and detailed in the ATAC report. They might be oversimplified by saying we believe advanced A & R technology benefits are needed to support the users of space. The recommendations are being implemented into the Phase B contracts and into the space station development through Space Station RFP reference to the ATAC report and a Space Station A & R Implementation Plan which will spell out the incorporation of A & R products from the contractors into the Engineering Master Schedule.

The cost of the ATAC recommendations will be included in the cost of IOC determined in Phase B. The practical considerations that will dictate which of these recommendations will be implemented are the application benefits, the costs, and specific technology readiness assessments.

Question 2: How do your recommendations differ from those of the Cal Space study?

Answer 2: The principal Cal Space technical recommendations and those of the ATAC report are essentially the same. (1) The Cal Space Panel recommended funding a long range technology advancement and demonstration program which ATAC referred to in its report but had not studied. Such funding was not in NASA's original plan for the Space Station, nor was funding which would be needed to adapt the basic technology advancements to space station systems. (2) The Cal Space Panel recommended a management organization including an A & R technology advancement activity outside the Office of Space Station. ATAC agreed with the concern (p.10) that the Cal Space Panel expressed about the Space Station Program managers having a formidable job without having to be responsible for long term A & R development but did not make a recommendation on a management organization. (3) The Cal Space Panel recommended creation of an external advisory board. ATAC did not make a recommendation.

Question 3: The Cal Space study on Automation and Robotics recommends that a minimally effective program serving some of the automation and robotics technology needs of the space station must reach $100 million by 1990 and that a baseline program of technology advancement and demonstration should reace ¢190 million well before 1990. To what extent can the space station funding profile accommodate automation and robotics funding of this magnitude?

Answer 3: The Space Station funding profile did not include any of the Automation and Robotics technology base advancement recommended by the Cal Space Panel and cannot accommodate funding of this magnitude.

Automation and Robotics R&D

Question 4: How much of the $8 billion space station program is currently allocated for automation and robotics research and development? Just what does NASA's projected level of funding provide compared to what a program of $100 million, or even $190 million, could provide?

Answer 4: None of the $8 billion Space Station Program is currently allocated for Automation and Robotics technology base advancement. NASA's projected level of funding provides those applications where Automation and Robotics is needed to accomplish the required basic functions. The recommendation contained in the Cal Space study report to initiate a research and technology program from $100 million to $190 million a year will result in capabilities that were not initially planned for the space station. These capabilities could provide a much more efficient space station and also would enable certain terrestrial applications to benefit our industrial base, but they would not be crucial for space station operations. Some examples of these capabilities that would result from this augmented research and technology program are: the generation of a natural language algorithm that will provide the capability for voice command of robots; the development of stereo vision in several spectral bands that could materially improve the efficiency of servicing remote satellites; the development of tactile sensors with force feedback that could provide materially increased efficiency to the space station dexterous manipulator as well as the servicing module of an Orbital Maneuvering Vehicle (OMV). The Cal Space study recommended the initiation of a broad based research and technology program that could underpin the development of these and other functional capabilities. This endeavor is not within the scope of the space station development effort, and, indeed, the Cal Space report recognizes that their recommended research and technology program is a completely separate endeavor.

Impact to Terrestrial Applications/Industries

Question 5: How will your recommendations, if implemented, affect or benefit terrestrial applications or industries?

Answer 5: Our recommendations are in two sets. The basic set is for the original $8 billion budget and is for application to the space station where Automation and Robotics is needed to accomplish the functions. The effect on terrestrial applications or industries is to make the current state-of-the-art more visible and perhaps more likely to be used. The augmented set of recommendations is if the NASA budget is augmented for technology base advancement and application of those advancements to the space station. In this case, substantially greater productivity benefits to terrestrial applications and industries is expected from the more capable technology base.

Initial Investment versus Operating Costs

Question 6: According to your testimony, using advanced general purpose technology could increase initial costs, but significantly lower operating costs. How should the trade-off be made between a higher initial investment which might lead to lower operating costs and the obvious constraints of controlling the initial investment? How can the costs of implementing first-of-a-kind technologies such as these be controlled?

Answer 6: A typical rule of thumb is that if an initial investment is repaid in 3 to 5 years of lower operating costs and increased productivity it is worthy of serious consideration. NASA will decide such issues in light of the original budget. The costs of implementing first-of-a-kind technologies can be controlled through maximum use of technology developed for others in Government and Industry and using only those which have the highest productivity.

Station Operating Costs

Question 7: Jim Beggs told this Subcommittee that annual operating costs for the Space Station might be in the neighborhood of $500 million. Does this figure take into account the implementation of advanced automation and robotics technologies? If not, to what extent might these technologies affect these costs?

Answer 7: There are 3 categories of Automation and Robotics for the Space Station. The first is those Automation and Robotics applications which are needed to provide required functions. The second is those Automation and Robotics uses which you will do trade studies to determine the benefits versus the costs. The third is the Automation and Robotics technology base advancements. The first category was included in Mr. Beggs figure, but not the others. Additional reductions in operating costs may be possible.

Investment in New Advances

Question 8: Your testimony suggests that, while the Space Station IOC will include many new advanced in automation, robotics, and artificial intelligence, a substantial R&D investment will be required to obtain truly major breakthroughs. How much of an investment are you talking about and over what period of time? Is this a task that should be largely Government-sponsored, or do you think that industry can step in and contribute?

Answer 8: ATAC did not study this cost, but the Cal Space Panel recommended a baseline investment reaching $190 million per year by 1990 and implied this level might continue will into the 1990's. Their recommendation was for amounts in addition to major industrial efforts and other government agency programs.

Drivers for Station

Question 9: According to your testimony, selected contractors were directed to identify "drivers", or factors for advanced automation, which might lead to the identification of representative systems or mission scenarios. What are some of these "drivers"? Do you believe that all of the relevant "drivers" have been identified?

Answer 9: One such "driver" was the automated maintenance of automated equipment. This is not now in the state-of-the-art but will be important in space in the future. Other factors were accommodating evolution and growth in A & R, use of knowledge-based systems and robotics, the necessity of the space station information system being supportive of A & R, and the necessity of capturing the design information to support fault diagnosis expert systems. While we have identified most of the relevant drivers, there may be others of which we are not yet aware.

International Initiative

Question 10: What discussions have been held with the potential international partners relative to this automation and robotics initiative? Are they comfortable with this initiative? Will there be significant difficulties in mating their systems and elements to our advanced automation and robotics technologies?

Answer 10: We have not held discussions with potential international partners on this initiative. Our assumption has been that the initiative is designed to stimulate U.S. technology development. Cooperation on advanced development topics will be on a case-by-case basis where it is determined to be in our mutual interest.

It is too early to tell how comfortable or uncomfortable the partners are with this initiative. Since it is an area of international competition, we have assumed they will be mounting their own initiatives.

The answer to this question is not known presently. One of the objectives of Phase B studies is to examine the interfaces between U.S. and international elements.

Design Considerations

Question 11: What Space Station design considerations are of importance to automation and robotics?

Answer 11: The Space Station design considerations that are of importance to Automation and Robotics are given in Vol II of the ATAC report, especially Chapter 4 which covers some 32 pages. Primarily they have to do with ways to take advantage of the benefits offered.

Question 12: You have stated in your testimony that NASA should make use of technology already developed for industry and Government. How can NASA determine what already has been developed, to avoid any unnecessary duplication? Does NASA intend to work with other relevant federal agencies that might assist in the identification of already-developed technologies?

Answer 12: The best way for NASA to determine what already has been developed is to have people involved in RDT&E in the field. Their full time motivation is to stay informed. NASA does intend to work with other relevant Federal agencies that can assist in the identification of already-developed technologies. Some of this is already underway with Defense Advanced Research Projects Agency, National Bureau of Standards, the Air Force, the Navy, and the Army.

Impact to Commercial Development

Question 13: How and to what extent are your recommendations likely to impact the commercial development of space? Is it likely that a company might choose to develop or utilize some of the technologies in your plan that are not adopted in the space station IOC?

Answer 13: ATAC recommendations will impact the commercial development of space through (1) improved flexibility to support innovation, (2) lower operating costs, making a profit more likely, and (3) having a most favored Automation and Robotics technology transfer status for commercial users of space. Through this latter mechanism, a company can choose to utilize some of the Automation and Robotics technologies whether or not they are adopted in the initial Station.

Question 14: You indicated that the contractor studies addressed only applications believed to be typical of those requiring advanced automation. What were some of these applications addressed in the contractor studies?

Answer 14: Some of the applications addressed in the contractor studies were operator/system interface, a space robot, two commercial manufacturing facilities, autonomous systems, assembly, satellite servicing, communications and some subsystems including ground support.

QUESTIONS OF SENATOR HOLLINGS AND THE ANSWERS

Space Station

Goals For Advanced Automation and Robotics

Question 1: In your statement you list several "preliminary goals" for advanced automation and robotics applications on the initial station. These are found in Table A. Are these "goals" the recommendations of the Advanced Technology Advisory Committee (ATAC)? To what extent do they reflect the inputs of the California Space Institute and the other outside contractors that assessed automation and robotics? Should these goals be prioritized or are all equally worthy of consideration in Phase B? Why are the goals limited to "enhancing" or "advancing" existing advanced technologies? Are there no technological breakthroughs worthy of consideration?

Answer 1: The goals are recommendations of the Advanced Technology Advisory Committee. They are consistent with the inputs of the Cal Space Panel and other study contractors, but are more specific. These goals, in addition to those A & R activities proposed by the Phase B contractors in response to the NASA RFP urging advanced A & R, are all equally worthy of consideration in Phase B. We do not view the goals as "limited" to enhancing or advancing existing advanced technologies since they are basically new applications not presently employed in existing spacecraft and one of the guiding principles is that we employ manual overrides until reliability is demonstrated and crew confidence is achieved. The mobile, multiple arm space robot is a technological stretch and the other goals are challenging applications of recent breakthroughs. We will remain alert to additional technological breakthroughs.

Guiding Principles

Question 2: In your statement you also list a series of baseline "guiding principles" or "recommendations". Were these "guiding principles" formulated by the Advisory Committee? To what degree were they shaped by outside groups? Do the "preliminary goals" included in the ATAC Report fulfill these "guiding principles" or "recommendations"?

Answer 2: The guiding principles in the ATAC report are based on listening closely to the Cal Space Panel technical recommendations and fine tuning them to the context of NASA and the Space Station Program. The achievement of the goals would essentially fulfill these guiding principles.

Phase B Studies

Question 3: There appears to be a great deal of confusion as regards the end use of all of the various reports that have been issued in the technology area. For example, the ATAC report consists of the recommendations of an internal NASA group that has obtained outside inputs. There also are the recommendations of the Cal Space group that represents an independent outside analysis. In addition, there are studies by McDonnell Douglas and five other contractors concerning the issues of the proper man/machine mix, human productivity and other space station issues.

Will you please explain how these recommendations will influence and shape the Phase B studies. Will Phase B contractors be tasked to design/define certain automation and robotics applications or will the contractors decide which, if any, of the recommendations they will pursue? Just what will be included in the NASA space station's implementation plan that is meant to ensure that Phase B will address automation and robotics?

Answer 3: The ATAC report is a reference document to the Phase B contracts, made so by the RFP. The ATAC report's technical recommendations do not differ substantially from those of the Cal Space Panel and other study contractors. All of the automation reports will go to the contractors. The Phase B contractors are tasked to define Space Station systems and to study the application of advanced A & R to those systems for decision by NASA as to the designs. The Space Station A & R Implementation Plan is likely to adopt the ATAC recommendations and spell out the A & R study products and due dates for the Engineering Master Schedule.

Question 4: In your statement you indicate that as a result of the Phase B activity, NASA will learn about the cost of the initial system, which could use this advanced automation and robotics, beyond what NASA would normally have employed. To what degree did NASA's original proposal include automation and robotics? What was the principle objective of NASA's original automation and robotics components -- reduced O & M costs, reduced extra vehicular activity, reduced ground support requirements, reduced life cycle costs, reduced performance of routine tasks? To what extent can advanced technology drive development costs? Can NASA determine what technologies are most promising for increasing space station efficiency and enhancing the nation's scientific and technical base leading to more productive industries here on earth?

Answer 4: NASA's original proposal included automation and robotics in the category of those applications where you needed A & R to accomplish the functions. The mobile remote manipulator, a crane-like robot arm, is such an example.

The principal objective of NASA' original A & R components was, as indicated above, those applications where A & R was needed to accomplish the required basic functions, that is, where needed capability had to be provided.

Advanced technology can drive development costs to the extent that the technology base must be advanced before space station applications can be made of those advancements and whenever additional applications may be indicated by trade studies to be of significant benefit, such as to reduce annual operating costs. The ATAC report based on Cal Space Panel input identifies the general purpose automation, robotics, and artificial intelligence technologies which are most promising for increasing space station efficiency (and effectiveness) and for enhancing the nation's scientific and technical base leading to more productive industries here on Earth.

Evolution of Space Station

Question 5: In your testimony you indicate that the Advisory Committee has come to believe that a great deal of automation and robotics may be needed on an evolving Space Station complex.

Does this mean that there will be a continuous need for advanced technology development funding in the Space Station budget? Does this infer that one's objectives for automation and robotics for IOC should not be set as high as Congress has instructed NASA?

In reality doesn't the ATAC report include two reports:

(1) One report that focuses on automation/robotics applications in the IOC: (2) One report that focuses on the automation/robotics requirements of an evolutionary space station that eventually will be fully automated?

Answer 5: There will be a continuous need for advanced technology development funding for A & R for the space station at least to leverage and exploit A & R technology developments for industry and other government agencies. If Congress wishes NASA to advance the technology base (over and above the applications to the space station) then additional funding would be needed.

The fact that additional major advances in A & R can be projected in the next two decades does not necessarily imply the objectives for IOC should be lowered. These objectives include accommodations for future technology as well as employment of near term state-of-the-art. The ATAC report includes the two aspects you mention, although "fully automated" means optimum human/machine mix.

Cal Space Recommendations

Question 6: Could you compare the principal Cal Space recommendations with those of the ATAC report? In particular could you address Cal Space's:

(1) proposed funding of a long-range technology advancement and demonstration program.

(2) proposed creation of an automation and robotics technology advancement activity outside the Office of Space Station; and

(3) the proposed creation of an external review panel or advisory board?

Answer 6: The principal Cal Space technical recommendations and those of the ATAC report are essentially the same. (1) The Cal Space Panel recommended funding a long range technology advancement and demonstration program which ATAC referred to in its report but had not studied. Such funding was not in NASA's original plan for the space station, nor was funding which would be needed to adapt the basic technology advancements to space station systems. (2) The Cal Space Panel recommended a management organization including an A & R technology advancement activity outside the Office of Space Station. ATAC agreed with the concern (p.10) that the Cal Space Panel expressed about the Space Station Program managers having a formidable job without having to be responsible for long term A & R development, but did not make a recommendation on a management organization. (3) The Cal Space Panel recommended creation of an external advisory board. ATAC did not make a recommendation.

Question 7: The Cal Space study states that "the government procurement cycle is now itself a serious impediment to Space Station use of advanced technology...there is a strong case for authorizing NASA to use such procedures (i.e., simpler, more rapid procurement procedures) for certain types of Space Station technologies." Would you please comment on this statement and inform the Committee as to whether or not the NASA procurement process needs to be changed to accommodate the use of advanced technology?

Answer 7: The NASA procurement for research and development is generally viewed as being as efficient as any other government agency. This agency is continually striving to increase productivity and reduce paperwork within the boundaries of the federal regulations. However it is felt that the procurements for the Space Station Program must be open to all qualified participants and competition maximized across all segments of industry as well as the academic community. Within this policy, there are certain procurement milestones which must be met and these milestones add a certain element of time to each procurement. Therefore, the process is sometimes viewed as lengthy. We feel this process is correctly structured to meet both the internally imposed management reviews and constraints as well as the government wide restrictions imposed on all our procurements.

Senator GORTON. Thank you.

Dr. Banks, your committee coined a new term, "telescience," to describe the communications mode you believe will most effectively serve the space station and scientific user.

How much would such a system cost? Could it become operational when the station becomes operational, and is NASA considering it?

Dr. BANKS. Well, I will defer the cost question, simply because I lack information about the costing issues and how they would be implemented within NASA. The answer to implementation is the technology exists today. It is basically a user requirement. It is a concept to try to increase the scientific productivity of operations in space, with low-cost telecommunications that have become a way of life. And we see it both in terms of direct video voice and other forms of telecommunication..

We are working very closely with Johnson Space Center in particular to try to define modes of telecommunication that will permit ground investigators to have almost a close connection to the space station and to interact with human resources as they go through the various experiment protocols.

My own personal guess is that this is not a question of expense. It is a matter of planning and recognition of the needs of the user community. There is a break with tradition involved, and it may take some time to evolve new sets of requirements in the sense that no longer will the principal investigators go to a particular NASA facility such as Johnson Space Center or the new facility at Marshall Space Flight Center, but instead will keep their teams at their home institution. It appears to be people can do this fairly easily with domestic satellite communications.

Senator GORTON. Is telescience compatible with the intiatives of Mr. Cohen's advanced technology advisory committee?

Dr. BANKS. Yes. We are working very closely together.

Senator GORTON. You stated that funds should be made available within NASA's Office of Space Science and Applications for the conduct of space station science so that the ongoing space science research that was unconnected with the space station will not be distorted.

How much would be required between today and the initial operating capability of the space station?

Dr. BANKS. I must say that we have not had formal presentations on the wedges available for science programming between now and IOC. The uncertainty appears to lie with the fraction of the original 1-percent augmentation that was promised to NASA; that is, what fraction of this would come back into the Office of Space Science and Applications for its programs.

There are two things that will certainly happen. One is that there is a heritage of experiments that are being based now on the space shuttle that will carry over into the space station era. Then there are new facility class experiments that will appear on the space station.

But certainly if I were to pull a number out of a hat, and based on my experience with these things, I would say that the program funds are short by several hundred million dollars per year. And if the situation is not rectified, then you will soon see a draining of funds into the new programs from programs that, as you are well aware, are already hard-pressed.

We feel a bit reluctant, as a task force, to make strong statements about precise crunching needs because we lack the staff support and the full internal knowledge of the NASA budgeting process, but based on experience of people on committees such as this and other similar ones, there is a true gap in the funding.

Senator GORTON. Mr. Cohen, according to your testimony, using advanced general purpose technology could increase initial costs but significantly lower operating costs. How should the tradeoff be made between a higher initial investment which might lead to lower operating costs and the obvious constraints which require us to control that initial investment?

Mr. COHEN. Well, in implementing the automation and robotics technology, there are three categories. I think Mr. Culbertson stated that. The three categories are: No. 1, there are the needs that the space station is going to need to do its job; that is, the needs, the technologies available, and the cost is within the budget. The second category is, you might say, a benefit. It could benefit the space station, but you really have to do a cost/benefit analysis to understand whether it is worth spending the money on the technology, the development, and the implementation, and then get the tradeoff on increased productivity or lower operating costs.

In order to do that, to really understand that, those trades have to be performed to see whether it is worthwhile doing. And during the phase B or the definition study, these tasks will be directed to the contractors to perform these tasks in order to make these tradeoffs to make that type of determination.

Senator GORTON. How can the costs of implementing the first-of-a-kind technologies such as these be controlled?

Mr. COHEN. Well, I think the first thing you have to do is not push the technology too fast. And the way you can take care of that situation is really by designing the space station with a transparent mode of accepting advanced technology or evolutionary type space stations, such that when the technology does become available, you can employ it on a space station.

This can also be enhanced by using ground test bids to test out your system and your technology or using the Shuttle for flight test beds to evaluate your systems before you actually pick up the implementation on the space station.

Senator GORTON. Your testimony suggests that while the space station IOC will include many new advances in automation robotics and artificial intelligence, a substantial R&D investment will be required to obtain truly major breakthroughs.

How much of an investment, and over how much of a period of time? And is it inevitably going to be a Federal Government investment as opposed to a private sector one?

Mr. COHEN. Let me see if I can answer the first part first—how much? My committee did not really look at the cost, at the dollars that it took to advance the technology. The Cal Space report did that. And in that report by a group of experts from academia and industry and Government, there was a significant sum in their report that said that in order to really advance the state of the art of automation robotics and artifical intelligence, a considerable sum of money had to be put into the research and technology, which was also category 3 in my category. That is the category where you really want to advance the state of the art. And that, of course, requires an augmented budget. It does take money to do that.

As stated in the Cal Space report, I do think that by stimulating it, we will get commercial people, commercial enterprise interested in extending the state of the art and putting their funds into it.

Senator GORTON. Thank you.

Senator Hollings.

Senator HOLLINGS. Thank you, Mr. Chairman. I am persuaded that we should move forward with the space station, but I doubt my ability to persuade others.

Dr. Banks or Mr. Cohen, suppose I go back home now and some political opponent jumps on me and he says, this fellow, Senator Hollings, has started an $8 billion program for a space station. And I say yes, that's right; I did it because * * * Will you complete that statement and give me one or two or three good reasons as to how would you answer, Dr. Banks?

Dr. BANKS. Well, I would first point out that it is not an abrupt new beginning of activities. NASA has a very successful program of valid scientific endeavors in space. These have been enormously beneficial to the United States and to the world in general.

We, up to the present time, have been in an exploratory phase where we were forced to send unmanned vehicles off into this hazardous medium, away from our planet. Our planet is one of many similar celestial objects in our solar system. With the technology in hand and the relatively low costs that are involved, we can for the first time, establish a foothold away from our planet. And with this, we will continue development in space in scientific areas and commercial applications that have not been possible before.

And I would emphasize to my constituency that it is a good investment and something they can be proud of.

Senator HOLLINGS. What practical or realistic result could anticipate seeing down the road as a result of advancing into space? Of course, the usual political rejoinder is, we have not solved the problems here on Earth; why should we be looking for a new area for new problems?

Are there any tangibles, Dr. Banks? Any tangible results that immediately flow?

Dr. BANKS. Well, if people are concerned about tangibles, the increased information about the state of our planet, including the weather, including dangerous storms, things that affect our lives in an ordinary sense. It has a less direct implication with respect to commercial activities; that is, improved products that perhaps are difficult or more expensive to produce here on Earth.

And I would point to the intangible intellectual aspirations of our civilization to understand its environment and its origins which certainly exist in a solar system. And I would find from my role at a university, that being privileged to teach about space and to communicate with people, that it touches a very positive response in virtually all people that comes to the university.

Senator HOLLINGS. Thank you very much.

Mr. Cohen, how would you complete this sentence? I voted for an $8 billion space station program because * * * Why should I vote for it?

Mr. COHEN. Somebody said earlier today and I agree very much with it—man has conquered the Earth, he has conquered the sea, and he has conquered the air, and man is going to be in space. I think you have to start with that premise that man is going to be in space.

I think we have to concentrate in this era of trying to solve man's problems on Earth from space, and you can do that in terms of Earth resources, satellites, spinoffs that we are going to get from commercial products, whether they be drugs or other pharmaceuticals materials.

So I think there is a commercial aspect of it. I think there are things that we can do to solve man's problems on Earth and I think that there are spinoffs. The spinoffs are probably a little bit more intangible, but they are there.

We talked about automation and robotics and I still feel very strongly that the spinoffs of automation and robotics from the space station can increase man's productivity on the ground, terrestrially. That is how I would answer.

Senator HOLLINGS. I understand from your study that by the year 2000, the space station would be operated in a robotic fashion?

Mr. COHEN. I think that that might—I do not think you could say in a robotic fashion. I think we are a long ways away from having man having a robotic system or an artificial intelligence system replace man. Manned intervention will be needed, but we will make man more productive in the things he does by having an automated system.

Senator HOLLINGS. I know the chairman and I both have to leave. But, Dr. Banks, with respect to telescience, what exactly is telescience? Watching, for example, the "Today" show, emanating from Rome, they are relaying it up on to a satellite and bringing it back from New York to my home. Is that the same thing, only instead of Rome you are in space and you are operating backward and forward the particular experiments and the research and the endeavors that we are making in space on that station there?

Explain once again telescience so that my constituents, and I too, can understand it.

Dr. BANKS. Well, I hope there is great benefit for everyone involved. The concept has grown out of the better understanding of the limitations of how space experimentation has been done in the past. You have to realize that because of resources involved and the hazards of the environment, most things we do in space in the scientific sense are programmed years in advance: We will do this and do that.

As a result, the spontaneous creativity that is associated with the human mind is largely lacking in these experiments. If you make a mistake in what you guessed you should be doing, and something else happened, you may have to wait 3 or 4 years to come back to try it again.

What we are attempting to do is to exploit rapid telecommunications technology to bring a true laboratory setting to the space station so that a principal investigator would be able to have a continuous update on the results that are being obtained from his experiments. This permits him to take advantage of the space-based resource with the aspects that cannot be done with artificial intelligence—the looking, the handling, the feeling, the seeing in space; to bring together this sort of triad into a real time synergism which is similar to what goes on in any ground-based laboratory.

Now, it is not a question of new technology; it is a question of thinking about who is trying to do what and where. And in this case, it is a harsh environment. It is not very far away; it is only a few hundred miles vertically. But it is a recognition of the importance of the customer in this case, that we are really doing many of these activities to support research to gain new knowledge. And the best way to do that is like we do it here on Earth, and this is an attempt to try to do that.

Senator HOLLINGS. Very good.

Thank you, Mr. Chairman. I will submit these other questions for the record.

Senator GORTON. Yes, we will have some additional questions for the two of you. We appreciate your help.

Would Dr. Drew, Mr. Simpson, and Mr. Oleson please come forward together?

STATEMENT OF DR. RUSSELL DREW, VICE PRESIDENT, PROFESSIONAL ACTIVITIES, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC., ACCOMPANIED BY TED SIMPSON; AND GARY OLESON, WASHINGTON STATE CITIZENS FOR SPACE

Dr. DREW. My name is Dr. Russell C. Drew. I am vice president of the IEEE for Professional Activities and chairman of its U.S. Activities Board. I am accompanied here today by Theodore R. Simpson, chairman of the IEEE Aerospace R&D Committee.

The Institute of Electrical and Electronics Engineers [IEEE] was founded in 1884. It is the world's largest technical society with about 260,000 members worldwide, approximately 215,000 of whom live in the United States.

Today, Ted and I would like to present the IEEE's views on the NASA space station. First, I should point out that, at a recent press conference on U.S. Civilian Space Policy, we advocated a five-point program for development of a permanent, manned space station. We believe that it is urgent for the United States to do the following: Commit now to the development and implementation of the infrastructure needed to continue man's active involvement in space; establish a permanent habitat for space crews and passengers in low-Earth orbit that will enable a full range of staging activities for future manned and unmanned missions; pursue international cooperation with qualified partners on three fronts: Shared funding, technology, and responsibilities; incorporated advanced remotely controlled systems as a complement to the on-board crew; and foster new and innovative opportunities for commercial industrial utilization of the manned habitat and other platforms.

Further, the pace of the program should not be such that other important space objectives in the science and applications programs are sacrificed.

I will focus my remarks on one particular aspect—international participation—and Ted will discuss space station planning.

INTERNATIONAL PARTICIPATION

The mandate for international participation in the U.S. civilian space program goes back 27 years to the beginning of the space program and the National Aeronautics and Space Act of 1958 which recognizes the need for international coopertion in space and encourages it for research purposes.

Futhermore, in his endorsement of the space station in January 1984, President Reagan stated that: "We want our friends to help us meet these challenges and share in the benefits. NASA will invite other countries to participate so we can strengthen peace, build prosperity, and expand freedom for all who share our goals."

There are many reasons why the United States has, and should continue to, support international particiption in its activities in space. Many of these reasons are neither technical nor scientific. However, in order for this participation to make sense, scientific and technical objectives must be satifisfied along with other economic, political, and diplomatic objectives.

In previous cooperative activities, NASA has followed the following guidelines: Cooperation is on a project-by-project basis; each project must be of mutual interest and have clear scientific or technical value; each participant bears full financial responsibility for its share of the project; each participant must have the technical and managerial capabilities to carry out its share of the project; and scientific results are made publicly available.

We believe that these guidelines have served the Nation well, and that they should also be used for the development of a space infrastructure which includes the space station.

The major international participants in the NASA space station are likely to be Europe, Canada—both of which participated in the development of the space shuttle system—and Japan. It is estimated that the development cost for the initial space station configuration will be about $11.5 billion. Of this, there are indications that Europe, Canada, and Japan may be prepared to contribute $3.1 to $3.6 billion, although no firm commitments have as yet been made by any foreign government. The foreign contributions have tentatively been defined as: $1.5 billion from Europe for a pressurized module and a large, free-flying platform; $0.5 billion from Canada for an unpressurized servicing module; and $1.1 billion from Japan for a laboratory module which would have both pressurized and unpressurized segments. In addition, Japan might also build a $0.5 billion large, free-flying platform.

As a transnational organization, the IEEE has benefited greatly from the contributions of its non-U.S. members. This is likely to be the case for international participation with the space station. The achievements of Europe, Canada, and Japan have demonstrated a sophisticated, technologically advanced space capability. Therefore, not only will the United States benefit by having a more capable space station, but also other countries will benefit by being able to participate in, and use the space station. The United States and its allies, working together, are capable of developing a space infrastructure with far more capability than could be developed if we do not cooperate.

At a meeting in Rome at the end of January, the council of the European Space Agency agreed "to welcome and accept the offer by the President of the United States to participate in the space station, with a view to continuing and strengthening a genuine partnership in the space field, subject to the achievement of satisfactory agreement." At the same meeting, however, the council also supported the eventual development of an independent European infrastructure which would include a space station (Columbus) and a space shuttle (Hermes). From our perspective, we believe that it would be better if the Europeans abandoned this "go it alone" approach and combined their planned space systems with U.S. efforts to create an international space infrastructure.

Now, Ted Simpson, who is also the editor of a recent book published by the IEEE Press, "The Space Station: An Idea Whose Time Has Come," will present the IEEE's views on NASA's planning for the space station.

NASA'S PLANNING

Numerous space station concepts and designs have been proposed and studied by NASA over the past 25 years, and their configurations and sizes have spanned a wide range—from two to dozens of crew members in space, and for orbital stay times from weeks to years.

The space station concepts of the 1960's and early 1970's focused on experimental and scientific data gathering. Some of these early objectives are being achieved with unmanned satellites and the spacelab flights aboard the space shuttle. Since the mid-1970's, space station conceptual thinking has expanded to include such operational tasks as space transportation support, manufacturing in space, and construction/assembly support for large space structures. Scientific experimentation continues to be emphasized in space station mission planning, but additional emphasis is now being placed on the station's operational potential.

Even before NASA landed men on the Moon in 1969, it began thinking about its next major step in space after Apollo. At that time, this was seen to be the development of a dual capability, that is, the development of the space shuttle and a space station. Since then, it has been recognized that both the space shuttle and the space station could become elements in a national—and possibly international—space infrastructure which would greatly increase our ability to operate in space. Other elements of this infrastructure would be the orbital maneuvering vehicle, the orbital transfer vehicle, serviceable free-flying satellites, and large, multipurpose platforms.

NASA's planning for the space station has accelerated as the number of operational space shuttle flights has increased. Phase A—mission requirements and concept definition—of this planning process took place from 1982 to 1984. Phase B—definition and preliminary design—will begin in April and be completed in January 1987. Phase C/D—design and development—will then be initiated to build the space station. The current plan is for the station to begin operations in 1993.

While it is regrettable that NASA has had to lengthen phase B by 3 months from 18 months to 21 months due to a reduction in its fiscal year 1986 space station budget of $50 million, the situation is not yet critical. However, we hope that further cuts in this year's budget and future budgets can be avoided so that further slippage will not occur. With NASA's current planning, the 1993 IOC date can be met, and we support this goal.

NASA has taken to heart the recommendation of the Hearth committee which in 1981 stated that the way to avoid serious cost overruns on a NASA project was to carefully define what was to be built at the beginning of the project. Phase A and phase B will more than adequately define what the space station will look like and how it will be used. During phase A, $30 million was spent in this definition, and during phase B, an additional $380 million will be spent.

The various user communities have taken an active part in defining their needs during phase A, and this process will continue during phase B. In addition, the modular design of the space station will allow it to grow and change as the needs of the users change.

Given this planning process as a background, I would now like to discuss briefly a number of technical issues associated with the space station. All of these issues should be resolved during phase B prior to the construction of the space station.

PERMANENTLY MANNED VERSUS MAN-TENDED

When you start to think of a space station, and why it should be built, you immediately confront a revolutionary idea—manned spaceflight. Arthur C. Clark has said that every successful revolutionary idea passes through three phases:

Phase 1: "It's completely impossible—don't waste my time."

Phase 2: "It's possible, but it's not worth doing."

Phase 3: "I said it was a good idea all along."

Clearly, we have passed phase 1—manned spaceflight can be done. We are now in phase 2—is it worth doing? This is what we are currently finding out with the space shuttle through such recent activities as the repair of the solar maximum mission spacecraft, the retrieval of two communications satellites, and the use of spacelab to perform research in space.

While we have thousands of years experience with unmanned satellites, our total manned spaceflight experience since 1961 is less than 4 man-years. Clearly, we ought to continue our manned experiments in space to broaden our knowledge base in anticipation of our greater use of space in the future. Space will become more important to us from both an economic and a national security perspective. The number and size of our space systems will continue to grow as our capability to operate in space grows. For this reason, permanently manning the space station makes a lot of sense, both scientifically and economically since it will allow us to gather the most information in the least time at the lowest cost.

As a side comment, I would like to mention that NASA, with the active participation of the various user groups, should lay out a road map of how it plans to use man in space over the next 10-20 years. This is something that is conspicuously lacking at the present time and that would be of use to a number of groups in formulating their future plans in space, including the National Commission on Space.

AUTOMATION

This issue is related to the issue above. In designing the space station and other elements of the space infrastructure, several guidelines should be kept in mind.

(*a*) The space station should be highly automated—the routine, simple tasks should be automated, allowing the crew to do only those tasks that are difficult to automate or that don't occur very often.

(*b*) Ground control of the space station should be limited. We shouldn't plan to have an army of controllers reviewing everything that is being done on board the space station. Rather, ground control should be limited primarily to research projects to reduce the overall cost of each mission.

(*c*) In designing the automation equipment, a balance will have to be struck between: Pushing the state of the art; allowing man to be a participant; cost; and schedule.

CONFIGURATION

It has to be recognized that building a space station is going to require a steady investment over a period of 20 years or longer. The initial configuration of the space station won't be completed until 1993. A growth configuration, including an orbital transfer vehicle, won't be finished until the late 1990's, and additional expansion is likely after that to broaden our manned spaceflight capability to include the capability to return to the Moon after the turn of the century. To accomplish this, the space station design will have to be flexible enough to include these long-term objectives.

TRANSPORTATION NODE CONCEPT

Both the commercial and the military user communities have been unenthusiastic about using the space station as a transportation node for the space shuttle and a future orbital transfer vehicle. This concept is going to have to be studied further. Due to the potential increased capabilities offered by such a concept, such as the transportation of payloads larger than those capable of being handled by the Centaur, I believe that it will ultimately be adopted.

POWER

As the power needs of the space station increase during the 1990's, the 75 kilowatts provided by the planned large solar array panels will have to be increased. Unfortunately, the growth in the size of these solar arrays preclude their use as the power demands rise to 300 kilowatts or more. At that point, either solar parabolic collectors or another form of power, for example, nuclear power, will be needed.

RECYCLING AIR AND WATER

While there might be a considerable saving in development costs by using an open-loop life support system which relies upon shuttle flights to continually resupply the space station's air and water, the operational space station costs could rise dramatically as the number of crewmembers increases. To avoid this, a closed-loop life support system should be used which recycles the space station's air and water, even though this will increase the development cost. The space station, while it cannot be made completely autonomous, should be designed to be as autonomous as possible.

CONCLUSION

In summary, we believe that: First, planning for the NASA space station is proceeding on schedule; second, while a small amount of slippage has occurred, it is not yet serious; third, technical issues have been identified by NASA and they will be resolved during phase B; and fourth, international participation is important, not only for the foreign countries involved, but for the United States as well.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. According to your testimony, NASA is not adequately planning how to use man in space over the next 10 to 20 years. What is the basis for this conclusion and why do you think there is a lack of effort on NASA's part? What steps would you take to correct this deficiency?

Answer. In our testimony, we discussed the need for NASA to develop a road map on how it plans to use man in space over the next 10-20 years. Without such a road map, each new project will seem ad hoc, and a disjointed event, rather than part of a consistent, progressively more challenging plan. Undoubtedly, a number of individuals at NASA have thought about various aspects of this question, but we haven't seen an overall plan on how NASA is going to gradually expand its use of man in space on a year-by-year basis. Granted that some activities will develop on an ad hoc basis, such as the repair of the Solar Maximum Mission spacecraft and the retrieval of the two communications satellites (Westar 6 and Palapa B-2), still many things can and should be planned by NASA in conjunction with the various user groups. This would guarantee that the maximum use would be made of man in space in the years ahead; not only for research and development, but in an operational sense as well.

Question. As you know, ESA is interested in developing its own space station. If ESA were to remove its elements from the U.S. space station for use on its own space station, would this present any problems for the U.S. space station? What could be done in the planning stages to minimize the impact if this were to occur?

Answer. While ESA is studying the possibility of building its own space station, Columbus, their current plans call for an IOC in the late 1990's. By that time, even if ESA withdrew a pressurized module from the NASA space station, it probably would not greatly affect the station. There is still plenty of time to resolve this problem in an amicable way with ESA.

Question. According to your testimony, both commercial and military user communities have been unenthusiastic about using the space station as a transportation mode for the space shuttle and the Orbital Transfer Vehicle. What is the reason for this lack of enthusiasm by these two communities and is their discontentment justifiable? What changes in the space station program are needed to accommodate their respective needs?

Answer. There is a natural conservatism in every user group which tends to favor continuing to do things in the future as in the past. The users would prefer to launch directly from the space shuttle and thus minimize any complications associated with the handling of their payloads at a space station. However, once the need and the capability exist to assemble large payloads in space, payloads that would require an upper stage that is larger than a Centaur, then the user groups should be quite willing to use the space station as a transportation mode. Greater utilization will occur naturally as experience with the station occurs.

Question. Certainly the Techology transfer issue is one of the most controversial issues related to international participation in the space station program. Since you represent an international organization that is intimately involved in technology development, could you provide us your thoughts on the potential problems associated with this issue?

Answer. Technology transfer, particularly with our allies, the Europeans and the Japanese, is not a black and white issue but rather one with various shades of gray. To maintain our leadership position in the aerospace field, the United States will have to continue to invest in research and development as it has in the past. Thus, it should protect those things which are at the cutting edge of technology. On the other hand, it should be willing to provide information on other technology to our allies on a quid pro quo basis. It was pointed out that there is technology transfer to the U.S. also, particularly with the growth in sophistication of our potential space station partners.

Question. Your statement points out the likely transition that may occur in space station power systems as power requirements increase. In your opinion, what is the ultimate power-of-choice—a solar dynamics system or a nuclear power system, and why? Do you think that either of these two systems could be developed and operational by the space station IOC?

Answer. At this point, NASA appears to be leaning toward solar power strictly for political reasons—the reentry of a small Soviet reactor from the Cosmos 954 spacecraft in January 1978 and the resultant widespread public fear of the consequences has made NASA reluctant to propose nucler power for the space station. We believe that this matter should be explored further before a final decision is made. Nuclear power would probably not be available by 1993 for the space station's IOC, but it could be added later on as the power needs of the station increase.

Question. According to your statement, NASA should strive to develop a closed-loop life support system, rather than use an open-loop system. What would be the additional cost associated with the development of a closed-loop system? Are there any technological barriers which might preclude its development by the space station IOC?

Answer. NASA is still developing the costs for a closed-loop life support system. However, whatever they are, we believe that they will be well worth the price if we are able to keep men and women in space for longer and longer periods of time. There may be some technological innovation required to develop a completely closed system, but there appear to be no technical barriers that cannot be overcome. It would be wise to keep open both options, and plan for modification that would permit introduction of a closed cycle system.

Mr. **Oleson**. Mr. Chairman and members of the subcommittee, thank you for inviting me to speak with you today. I represent Washington State Citizens for Space and the International L5 Society, nonprofit groups that work to promote our future in space. I am not a space scientist or engineer; I am a professional statistician who volunteers to organize pro-space activities. In this regard, I am most like the people who organize your county and State reelection campaigns.

I work alongside thousands of volunteers who give thousands of hours and thousands of dollars to see that we develop the potential of space. Why do we do it? Because we are fans of NASA? No, through we praise its deeds. Because we like space hardware? No, though we are inspired by the space shuttle. Because of the adventure? In part—many of us would like to live and work in space someday, all of us are excited by our advances in space, and we are proud of the United States for its leadership. But the thing that makes us workers, instead of just fans, is the hope that space provides for a future of freedom and prosperity for our children and our grandchildren.

We fear a future in which we limit ourselves to only one planet. We foresee a time when we truly begin to exhaust the limited resources of the Earth. If we do not reach for resources beyond the Earth, we will eventually reach limits to growth that will lead to stagnation, poverty, and tyranny for most of humanity.

Our goal is to open the solar system for the expansion of human civilization—to learn what can be learned—to use what can be used. Our own Moon and hundreds of asteroids lie close at hand. Beyond them are planets and moons, asteroids and comets, waiting to teach us more about the universe and to provide the resources we will need. A continuous supply of solar energy flows through space for our use.

You have perhaps heard space called a luxury. It is precisely the opposite. Investment in space is essential to our Nation's future. Satisfying most of today's seemingly urgent demands will create no new wealth for the future. Most ask only for immediate benefits. They can be to us what bread and circuses were to the ancient Romans; they can be the real luxuries. We risk buying today's prosperity at the expense of furture generations.

I have said our goal is to open the solar system. We first need a national laboratory is space to learn to use this new environment to our advantage. We will learn more about the workings of nature, create new processes and products for industry on Earth and in space, and learn more about the nature of life. The new space sciences will help establish leadership in fields such as automation, electronics, medicine, communications, and metallurgy for whoever developed them.

Government funding for this laboratory is essential. Most companies will not invest in projects that require more than 3 years to produce a marketable product, especially in the violatile high-tech industries. A permanently manned space station will provide the basic science from which new industries are built. It will also reduce both lead times and costs in the development of new products and services. The opportunity for frequent and varied experimentation may cut product development times by a factor of six.

Experience gained on the space shuttle emphasizes the need for people in space. Last August, Astronaut Charles Walker, industry's first private payload specialist, saved an important drug-processing experiment. Without constant attention by Walker, the product return would have been minimal or none. A fully automated laboratory that can do such work is beyond our present capability. Keeping scientists on the scene is our only choice.

Along with the laboratory, we need to develop capabilities for on-orbit testing and construction of larger satellites and space probes, of large communications platforms, and of large industrial facilities to provide the new products and services made possible by space. Here the results of research will be applied to our direct benefit.

Beyond that, we must explore the Moon and begin to use its resources. Our Moon is the proving ground and source of materials that will let us reach the rest of the solar system. The third goal of

NASA's space station should be to support a prompt return to the Moon, this time to stay.

We need to prepare for the opportunities that the space station will provide. This means pursuing a vigorous program of research on the ground, making maximum use of the shuttle for research, and using space probes to prospect for resources on the Moon and on nearby asteroids.

We also see a trap for NASA's Space Program, a trap that can distort our purpose and waste our energy. That trap is for NASA to become the permanent operating agency for the capabilities it creates. NASA should not long remain a transport company, nor should it become a permanent landlord for factories in space, nor permanently operate a service station for broken satellites. We need all of NASA's energy to drive research and development as far and as fast as possible. Other Government agencies and private industry should take over the operations as quickly as feasible.

"In Search of Excellence," the nationally acclaimed study of American industry, identifies "a bias for action" as a key element in any successful endeavor. Organizations that study, study, and restudy a project, in hopes of achieving a perfect solution, fail or succeed too late. This lesson applies to the space station as well. The time to act is now. Debate on the uses of NASA's space station should and will continue. To delay the program pending the outcome of such debates will only increase the costs and delay the benefits.

We believe the space station is an enterprise of great urgency. The space station is not just a moneymaker—it is an industry maker. No other Government investment will do so much to create jobs, advance technologies, and improve the quality of life here on Earth. We ask that you support full funding for the space station and that you strive to hasten its opening.

The Founding Fathers of our Nation made plans not just for one generation ahead, but for two or more. Their wisdom is shown by such acts as the Louisiana Purchase. Now, we look ahead one decade and call it long term. If we do not regain the vision of our forefathers, we may not have a future.

Space offers us opportunity, freedom, prosperity, and hope. As the Office of Technology Assessment said last year in their space station report, "we can move civilian space activities into the mainstream of America's—indead, the world's—interests, reap great political, social, and economic benefits, and very soon begin to have our men and women strike out across the solar system."

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. In your testimony you have alluded to the opportunities and potential benefits that could result from international participation in the space station program. Could you expand on this idea and also comment on the political implications of international cooperation on the space station program?

Answer. We can get far more out of cooperation than competition. Making the space station an international effort will bring the nations of the earth closer together. Cooperation will prevent duplication and will allow each nation to do what it is best at.

So far the United States has been the world leader in the development of space. If we don't lead the space station effort, other countries will and the United States will be left out of the exploration and development of space.

Our space station effort must reach out to the third world. The third world countries can benefit greatly from the new view of their lands and resources that can gained from space station. The same infrastructure that would allow use of space station to the third world countries would also support other small users . . . individual enterpreneurs and small start-up companies.

Question. You have mentioned that there is an endless number of potential opportunities that could result from commercial space station activities as well as from scientific research activities unlike any others that have been conducted. What are some of the likely applications from these activities that could significantly impact our lives here on Earth?

Answer. The number one immediate area of impact is in the fields of medicine and pharmaceuticals. Developments in these fields could save countless numbers of lives. For example, research is ongoing in the areas of diabetes, hemophilia, and sickle cell anemia, and it is possible that only space-based processing will produce new life-saving or life-prolonging drugs for these diseases. Also, space may be the best place to treat severe burn victims.

The automation and robotics technologies developed to make the space station more autonomous will have numerous applications and spinoffs in earth based industries. The availability of new materials and new methods of processing known materials will have dramatic impact on building materials, cars, electronics, even kitchen utensils, here on earth. Servicing of satellites will be more responsive. For instance, the weather satellite which went out of service in 1983 diminished the quality of forecasts in the Pacific Northwest . . . a station could have responded quickly.

Probably the most important impact will be that we will look at problems from a new perspective leading to better and different solutions.

Question. Much has been said about the need to ensure that the ultimate space station infrastructure is a truly NATIONAL asset which will benefit most, if not all, elements of our society. Do you think that NASA's current planning reflects such an approach?

Answer. NASA's space station plans are now in the concept definition stage. It is difficult to see the effects of their planning when it is incomplete and ongoing. Assuming their past record, the result will be very good but not far reaching enough. We would also like to ensure that NASA's planning incorporates means to transfer operations to the private sector at some well defined point in the program. Historically, on shuttle for example, NASA has gone beyond their charter as a research and development organization and is marketing and operating the resultant product.

Airlines and railroads work best in a competitive market and the shuttle probably would too. We feel the principle of private enterprise would apply equally to the space station. For example, government now provides services such as roads, sewage treatment, power, water, etc. to earth laboratories . . . and for new technologies government provides seed money to advance basic research in risky areas of inquiry. The role of government in space should be similarly applied. We note that on earth private companies direct the research and government intervention is minimal to non-existent.

Question. What role do you envision the space station having in our country's space activities in the 21st century?

Answer. In the 21st century there will be numerous commercial space facilities run by American companies and by other countries. The space station we are currently discussing should always be maintained as a "cutting edge" research facility to advance new fields of inquiry. This facility should probably specialize as a staging base for government sponsored planetary expeditions, which is the least likely area to be commercially developed. Governments sponsored Christopher Columbus and the Lewis & Clark expeditions and should continue to promote advancement of our knowledge of the universe. From the space station we could launch manned expeditions to Mars, the moons of Jupiter and Saturn, and other exciting places in our solar system.

We believe that in addition to science and commercial activities, tourism will become a very big business and this first space station will need to accommodate their visits.

We have only cursorily answered this question. Washington State Citizens for Space is in the process of preparing a comprehensive plan to cover all aspects of space activity which is due out in late summer or early fall of this year for submission to the new National Commission on Space.

Question. In summary, what one note of advice would you, as a representative of citizens space advocacy give to congress as we continue to examine this proposal to develop a permanently manned space station?

Answer. Our advice would be to not slow down or cut back but rather to accelerate the deployment of the space station facilities, keeping the design within the context of what we plan to do beyond the space station effort. The station is in a concept definition stage and now is the time to adequately fund the program to ensure good design. At a similar stage in the shuttle development program, money was cut back and that later resulted in a late program with large cost over-runs.

Remember what it felt like when we—America—were going to the moon! That feeling is still out here, just as strong: the desire to feel pride in America's accomplishments, to have a sense of shaping the future . . . and not having to stomp on some little country to do it. Let's not lose the opportunity we have to expand our knowledge, to expand our sphere of activity, to expand our national wealth and to increase our individual well-being.

Some things you must do for the right reasons and some things you must be because, they are right in themselves. Expanding the United States' horizons in space encompasses both. We urge you to fund the space station for the full $230 million that the administration requested.

Senator GORTON. Gentlemen, the chairman is simply going to have to apologize to you. It is after 12, and he has a 12 o'clock engagement. He had no idea that so many members of the committee would be here today with so many questions.

As a consequence, I am simply going to have to put the statements of each of you in the record. I have been on the other side of these tables and I know how frustrating it can be to wait through an extended period of time like this. We try to take the people who are from out of town first on the list.

At this point I can only apologize and say that each of you will be treated in the record as having given the statement involved. I have been briefed on them. We also have a number of questions for you, as well, which we would like to submit to you and to which we would like to get answers.

As you know, you have been watching this nice model and you saw the movie. The whole project is somewhat at risk, given the nature of the budget debate here this year, and we need all the information we can possibly get in order to have a real opportunity of keeping it going.

Each of you is an important part of that. But I am sorry; I didn't have any idea that it was going to last this long and deprive you of this opportunity.

The subcommittee is adjourned.

[Whereupon, at 12:07 p.m., the hearing was adjourned.]

NASA AUTHORIZATION FOR FISCAL YEAR 1986

THURSDAY, APRIL 4, 1985

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY AND SPACE,
Washington, DC.

The subcommittee met, pursuant to notice, at 10:15 a.m., in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

CLOSED SESSION

Senator GORTON. Secretary Aldridge, my apologies for being this late.

Do either of you have opening statements?

Senator GORE. No.

Senator GORTON. Senator Rockefeller, do you have an opening statement?

Senator ROCKEFELLER. No. I never do, Mr. Chairman. But I do have statements for the record from Senators Hollings and Riegle.

[The statements follow:]

OPENING STATEMENT BY SENATOR HOLLINGS

Mr. Chairman, in the course of the last year, more newsprint has been dedicated to the NASA/DOD rift than at any point in the history of the Nation's space program. Since the January DOD shuttle launch, it is quite clear to everyone that our civilian and military space programs interact. Hopefully, during the course of today's hearing, we will find out to what degree these programs interact and how NASA and DOD plan to reconcile their differences and jointly ensure the technological leadership of the Nation's space program.

Interagency cooperation has been one of the cornerstones of the space program since its inception. As we are all well aware, the National Aeronautics and Space Act of 1958 clearly recognizes the interrelationship between the Nation's civilian and defense space activities. Thus, it is not surprising to see NASA and DOD jointly pursuing new technologies (such as the Centaur Upper Stage) or jointly utilizing existing technologies (such as the space shuttle). It is of concern to the Committee, therefore, when interagency disputes, rather than interagency cooperation, become the norm. While I am aware that the recent National Security Directive resolved *most* of the outstanding NASA/DOD issues, I am still concerned that the cooperative spirit of the first 25 years of the space program is being supplanted with a competitive spirit.

Today, this Committee will take a look at a variety of issues that involve NASA and DOD including the proposed DOD uses of the space station, shuttle pricing policy, NASA/DOD development of a second generation space transportation system, refurbishment of Titan II ICBMs, SDI shuttle use requirements and NASA/DOD efforts to promote commercial space activities. It is my hope that as the Committee reviews these issues, it will discover that joint cooperation between NASA and DOD is back on track.

Mr. Chairman, I look forward to the testimony of the distinguished Under Secretary of the Air Force, Mr. Aldridge, and to his views on the status of the Nation's space program.

OPENING STATEMENT BY SENATOR RIEGLE

Mr. Chairman, I would like to welcome Under Secretary Aldridge and indicate that I am most interested in his testimony.

In the course of the last few years, a very subtle transition occurred that for the most part went unnoticed—the Nation's space budget shifted from civilian program spending dominance to military spending dominance. This shift first occurred in 1982 when for the first time in 22 years, the Pentagon's share of the space money edged past NASA's share. Today, nearly two-thirds of the total U.S. space budget of $24 billion is military spending, excluding Star Wars research and development activities. The remaining one-third, $8 billion, is NASA spending.

In light of this shift, it is not surprising that the "militarization" of space has come to dominate public perceptions of the space program. That is why it is so important for this Nation to reinvigorate the civilian space program with the space station initiative and to establish a clear course of action through the recommendations of the National Commission on Space.

Mr. Chairman, in the course of today's hearing, we will explore the relationship between DOD and NASA and between our civilian and military space program. We will assess on-going programs and look at future activities that will require close cooperation between NASA and DOD, in particular the space station and the development of a second generation space transportation system. At the same time, we will be fully briefed on DOD expendable launch vehicle requirements and how they impact the shuttle manifest.

At the end of this hearing, I am hopeful I will be convinced that the recent National Security Directive has resolved the principal differences between NASA and DOD and that the Titan II issue also will be resolved in the best interests of NASA, DOD, and the Nation.

The U.S. civilian/military space initiatives are of fundamental importance to the technological leadership and national security of this country. I look forward to today's testimony and to evidence of DOD's commitment to promote space programs for the benefit of all mankind.

Senator GORTON. Well, I am always going to ask.

Secretary Aldridge, you may proceed.

STATEMENT OF EDWARD C. ALDRIDGE, JR., UNDER SECRETARY OF THE AIR FORCE

Mr. ALDRIDGE. Thank you, Mr. Chairman. I am pleased to be here to respond to the committee's request for our current views on the DOD space program and particularly those relating to NASA.

I have a formal prepared text that I will submit for the record.

Senator GORTON. It will be included in the record in full.

Mr. ALDRIDGE. But I will provide the committee a brief oral summary of that prepared text and, of course, will be happy to answer any questions you may have.

Specifically, I would like to discuss the success of the January shuttle mission and its inertial upper stage [IUS] and, second, the status of the Vandenberg launch and landing site, and, finally, our views concerning the DOD space launch strategy.

I am most pleased to announce our complete satisfaction with the performance of the shuttle "Discovery" and the inertial upper stage on Mission 51C that was launched January 24, 1985. This was the first dedicated DOD flight. While the mission still remains classified, I can say that the IUS worked well. Of course, on STS 6 in April 1983, the IUS had a serious malfunction while launching a tracking and data relay satellite for NASA.

The performance of the IUS on 51C was well within the specifications for the mission. Thus, we are once again on a successful track.

In spite of the unfortunate publicity of this flight, there was an unprecedented level of cooperation between NASA and the Air Force in carrying out this mission to its outstanding success. There is no doubt that this spirit of cooperation will carry forward to future DOD flights.

The Vandenberg launch and landing site is another outstanding example of DOD and NASA partnership and cooperation on the STS. With no major problems noted, everything is going better than expected, and we are on schedule.

The Air Force has almost completed the construction and testing. To date we have successfully run the nonflight space shuttle "Enterprise" through its paces in the facilities, culminating with stacking it, an external tank and inert solid rocket boosters, on the launch pad. All the large mobile structures have been moved and made ready for stacking the Enterprise. I brought pictures of the final results, Mr. Chairman, and I believe they are being passed around.

The external tank for the first Vandenberg flight is already on the base in storage. We are on track to be able to support launches after October 15, 1985. That is the date of our initial launch capability. However, the first shuttle mission is not scheduled until March 1986.

As a result of NASA's concerns about the effect of their orbiter tile problems on the remainder of their manifest for this year and as a result of our concerns we had over the completion of testing of our payload for the first Vandenberg flight, Mr. Jess Moore, of NASA, and I mutually agreed that it was in the best interest of both agencies to slip the first Vandenberg launch until no earlier than the end of January 1986. We have now adjusted the first launch date to March 1986 to permit a flight readiness firing.

Next, I would like to turn to our space launch strategy. The requirement for assured access to space derives from the ever-increasing importance of space assets to our national security. The Defense Department requirement for assured access to space under conditions of peace, crisis, and conflict is a validated and urgent requirement which has been stated unambiguously in several administration policy documents.

The need for assured access to space is fully consistent with the President's July 1982 national space policy. The requirement for a complementary expendable launch vehicle is the product of many space architecture and launch vehicle studies as well as the DOD net assessment of the total space operation and space launch posture.

The CELV requirement was restated by the President in his 1984 National Space Strategy and by the Secretary of Defense in a February 1984 memorandum, Defense Launch Strategy. This need was further endorsed by the National Research Council report chartered by the Congress in 1984, and most recently by the President's

National Security Launch Strategy.

As you know, this has been a highly emotional and controversial issue over the last year or so. Let me say that it is often a misunderstood issue. This misunderstanding has been related to a misconception that the CELV was only a ploy by the Department of Defense to abandon the shuttle. Nothing could be further from the truth.

For the past several months Jim Beggs and I have been working to alleviate the concerns of both NASA and the DOD with regard to the CELV, shuttle and future launch vehicles, and have come to a major agreement, as reflected to the President's National Security Launch Strategy, dated February 25, 1985. Let me summarize that agreement.

First, we will work together to ensure the shuttle is a viable operational system heading toward 24 flights a year. Second, NASA will agree with the need for a complementary ELV to the shuttle, with the Air Force buying 10 vehicles to be launched at 2 per year in the 1988 to 1992 timeframe. The type of ELV has been chosen by the Air Force through a competitive process. A Titan derivative, the Titan 34D7, is the winner of this competitive procurement.

Third, DOD will commit to at least one-third of the available STS flights over the next 10 years. Let me add this is, independent of and in addition to, the number of ELV's to be flown during that period.

Fourth, we will develop a pricing policy for STS flights that will give positive incentive for DOD flights on the shuttle.

Fifth, we will work together on a second generation space transportation system using manned and unmanned systems to meet all user needs.

And, finally, any changes to this agreement must be agreed to by DOD and NASA and approved by the President.

Mr. Chairman, we are very happy and encouraged by this agreement and believe it sets us on a new course for future launch capabilities of this Nation.

The Air Force is taking another step in launch vehicle procurement. As part of his strategic modernization program in 1981, the President's announced his decision to deactivate the Titan II intercontinental ballistic missiles. As I reported to this committee last year, the Air Force initiated a study to determine if there were a cost-effective use for these residual national assets.

We have had some Defense programs that require small launch-on-demand satellites to be infrequently placed in unique low altitude polar orbits. The study found that the Tital II could meet the launch needs of these small Defense payloads, such as the Defense Meteorological Satellite Program, the DMSP.

Based on successful experiments with the Atlas ICBM and the Thor IRBM conversions to space launch vehicles thirteen of the Titan II's currently being deactivated from three bases in the United States. We plan to convert these 25-year-old missiles into space launch vehicles for use only for west coast for launches from 1988 to 1995.

The use of the Titan II instead of the shuttle for such programs makes economic and programmatic sense. For instance, the DMSP's unique polar orbit and launch-on-demand schedule would require a dedicated shuttle launch for this one small payload, which could use less than 10 percent of the shuttle's polar launch capability, which does not require manned intervention, and which does not lend itself of mixing with other missions.

This would be an extremely inefficient and ineffective use of the shuttle. Using the Titan II's frees the orbiters to be used on other more efficient and profitable missions. The total cost to the taxpayer for the Titan II space booster launch would be about $30 million. Employing Titan II's as launch vehicles is a responsible use of the prior national investment is these missiles. Rather than scrap them, we will get a productive use from then, much as we have done in the old Atlas and Thor ballistic missions.

Costs to accomplish this are $65 million in fiscal year 1985 dollars for the initial conversion, and approximately $15 million apiece for refurbishment. This DOD initiative is reflected in the fiscal year 1986 President's budget.

As a nation we should have the most versatile and capable launch system anywhere. I believe we have the opportunity facing us today. We must create an environment where the launch capacity of each of our separate space sections—civil, commercial, and national security—complement each other rather than compete. We must foster all these capabilities and use each in its most advantageous application in order to maintain our national space transportation leadership.

This concludes my remarks, Mr. Chairman. I will be happy to answer any questions you may have.

Senator GORTON. Thank you very much, Mr. Secretary.

For how many Titan II's do you have DOD payloads scheduled right now?

Mr. ALDRIDGE. We have 56 available Titan II's that will be deactivated, and the plan at this point is to use 13 of them for space-launched vehicles—six for the DMSP, six for a classified payload, and one for the Navy remote ocean and sensing system satellite called N-ROSS.

Senator GORTON. What are those other types of payloads beyond the DMSP's?

Mr. ALDRIDGE. They are classified, sir, and I would have to go beyond the classification of this hearing.

Senator GORTON. You mentioned in your testimony that the Titan II is a more efficient means of launching the DMSP satellites than the shuttle. Is this true for all of the payloads for which you are presently designing the Titan II's?

Mr. ALDRIDGE. Yes, sir. The DMSP and the classified payload are roughly on the order of 3,000 pounds total payload weight. The shuttle is capable of lifting 32,000 pounds into those types of orbits. We believe that the use of the Titan II for launching the small satellites, which are launched upon failure of on-orbit satellites, can be launched quickly, efficiently, and without using a major vehicle such as the shuttle.

The shuttle can, therefore, be used for other more reasonable and more effective roles. We believe that the use of the Titan II is a much more effective way to get those particular vehicles into space.

Senator GORTON. Has NOAA decided whether it will use the shuttle or the Titan II's to launch its three Metsats, K, L, and M, and, if not, when do you expect that decision to be made?

Mr. ALDRIDGE. Sir, we had had some discussions with NOAA about the possibility of using the Titan II's. We have not been given a final decision whether or not they plan to do that. I know they are in discussion with NASA about continuing to fly on the orbiter. We have not been given any final decision, and I do not believe I have any date on which that decision will be made.

Senator GORTON. Do you have any view from your own perspective as to whether the shuttle or the Titan II is the more efficient and cost effective way in which to launch those satellites—not from a point of view of DOD or any other agency, but from the point of view of the United States as a whole?

Mr. ALDRIDGE. Yes, sir; I do. The NOAA satellites are very much like the DMSP satellites. They are very small. They go to polar orbit. They replace the failed satellites on orbit, and they cost roughly on the order, for the DMSP for example, $70 million to convert the DMSP satellite that currently flies on an expendable booster to the Titan—or to the shuttle would cost $70 million to provide that conversion from ELV to Titan.

NOAA estimates, and these are from NOAA and I have no way to validate the accuracy of the number, that it would cost about $90 million to convert the NOAA satellites to the shuttle mission. If the Titan II is available, of course, that cost to the taxpayer can be avoided.

The cost to fly a NOAA satellite on the shuttle, if it is a full shuttle payload, is very expensive, depending on which dollars you use, roughly on the order of $80 million to fly a full shuttle mission, versus $30 million to fly on the Titan. There is a possibility you could mix payloads, but that has yet to be determined, whether or not you could find a payload that could fly on the day that you want to fly the NOAA satellite and orbit you want to fly it and get the benefit from that orbit for the other missions that would fly in the mixed payload.

I believe that the NOAA satellite could fly just as efficiently on the Titan II just as the DMSP flies efficiently on the Titan II.

Senator GORTON. Thank you.

By using these Titan II's to launch your select payloads you, obviously, have reduced the number of possible shuttle payloads requiring a polar orbit launch from Vandenberg. Taking into consideration the Titan II launches and the answer that you have just given, could you tell the subcommittee what your projected shuttle mission model at Vandenberg is for, say, the 1987-95 period?

Mr. ALDRIDGE. Yes, sir. We are capable of launching up to four shuttle missions per year out of Vandenberg. We could launch more than that, but require additional facilities there to provide that capability. We plan to use to the maximum extent possible the facilities at Kennedy to help support those Vandenberg launches.

If we got beyond the four, we would require additional facilities. Our mission model now shows us climbing to about three and a half per year in the late 1980's, and possibly exceeding five launches per year in the 1992 to 1995 period.

Senator GORTON. So you are not losing anything in cost efficiency?

Mr. ALDRIDGE. No, sir. As a matter of fact, we have gone back to take a look at the mission model because there are some projections based upon, perhaps, some aggressive program management showing us getting as high a seven missions per year out of Vandenberg if the strategic defense initiative continues R&D and development activities.

We do not have any problem with using up our available facilities at Vandenberg at this point, sir, and do not believe that the removal of the DMSP satellites from the shuttle will make any impact upon the Vandenberg launch rate.

Senator GORTON. What is the likelihood and under what circumstances will there be launches of more than 10 CEIV's during the 1988 to 1993 period?

Mr. ALDRIDGE. The only conditions I can think of where we would need more than 10 are if we had a major failure in the shuttle program, if one of them crashed or we had to ground the shuttle fleet for a long period of time until we resolved a problem.

Right now the number of satellites that we have planned to fly are only 10 during that timeframe, 2 per year. Those are the only ones that are being coverted so they can fly on the ELV as well as the shuttle, and only in the case where we had a major failure in the shuttle program would we come back to the Congress and ask for additional flights during that timeframe.

Beyond that timeframe will depend upon how successful we see the shuttle can meet the 24 flights per year, how successful our space program is, how much demand we are placing on the shuttle for future capabilities, and the type of thing that would have us look toward an expansion of the 10 would be something that would be depending on how well the shuttle is successfully meeting its mission model.

Senator GORTON. Can you identify requirements for a CELV after 1993 that the similar to the requirements that led you to the present decision?

Mr. ALDRIDGE. Only in the condition that the current flight rate is not being achieved or that we find that we have filled up the shuttle mission model with the 24 flights per year and DOD needs additional flight rate. And only under those conditions would we go beyond the 1993 period.

Senator GORTON. Do you have any contingency plans in the event that the CELV is not launch-ready by October 1988? Can you go back to NASA in those circumstances?

Mr. ALDRIDGE. Yes, sir. That will be the only choice. The one option if the CELV is not available in the late 1988 period is to fly that payload on the shuttle.

Senator Gorton. And would it be available?

Mr. Aldridge. Yes, sir. That payload in the early period would be dual compatible to fly either the shuttle or the CELV.

Senator Gorton. Did you consider the opportunity or the possibility of simply using the CELV's as a backup, with the shuttle as the primary launch capability?

Mr. Aldridge. Yes, sir; we did, but it does not make economic or programmatic sense. We still have to buy the CELV, so in a sense we would be buying two launcher rides for each satellite. We just cannot afford that.

The second is that, well, could you buy a few of them and put them in storage? To launch spacecraft is a very complex and skillful type of endeavor. We need a highly proficient launch team to launch those vehicles. You just cannot put a vehicle in storage, pull it out, and launch it on any given day without having a proficient team there available to fly that vehicle.

Once you have paid for the launch team, and it must practice every so often to maintain that proficiency, much like we fire the Minuteman and Titan missiles today. Once you have made the investment in the practice, and made the investment in the launch vehicle, we might as well use them. That was what we planned to pursue.

Senator Gorton. Will all payloads for the CELV be shuttle-compatible?

Mr. Aldridge. Yes, sir; eventually. [Deleted] will be dual-compatible from the beginning. Let me make one correction.

[Deleted.]

It costs a lot of money to make it dual compatible, but when we can do the block change we can design that dual compatibility into the vehicle from scratch it is very much cheaper, and that is the plan. So they will be eventually, not all at the initial stages of the CELV program.

Senator Gorton. Your testimony is consistent with most assessments, regrettable as it is, that a fifth orbiter cannot be justified at the present time. What possibility do you think there is that potential SDI requirements might increase demand enough to justify a fifth orbiter?

Mr. Aldridge. I would put it not just SDI. I do not believe we fully have integrated the space station requirements into the manifest of the shuttle. I think both of those combined for the future—of course, it depends upon the pace at which we proceed with the development of SDI and the research programs that go along with that—but I believe the space station and SDI could place additional demands upon the shuttle for flights beyond the 24 per year that would result in a view toward looking for a fifth orbiter.

But let me say it is not just the fifth orbiter you have to look at. It is the ground facilities that support it as well. I believe Mr. Beggs in testimony a few days ago has said that he has some problems with getting the orbiters through the ground facilities to get them launched fast enough. Just having a fifth orbiter does not mean you can add 12 more missions or 6 more missions a year, because you have to process those orbiters through the same facilities.

So it may be a combination of fifth orbiter plus additional facilities that allow you to benefit from the additional launch rate that may be required in the future.

Senator GORTON. As you know, Mr. Secretary, NASA has run into some problems with its TDRS satellite system, and we now are subject to an indefinite delay in the launch of TDRS B. Does the delayed deployment of TDRS B and C affect your operations or any of your launches or missions?

Mr. ALDRIDGE. Not so long as we can get those missions off. I believe the mission now is to launch TDRS C, which would be a fix of the current problem, late this year, and therefore try to get TDRS B off early the following year. If those schedules hold, there will be no impact. However, if those start slipping toward the later part of next year, they will have a significant impact upon us.

Senator GORTON. According to your testimony, the high reliability of our domestic ELV's is an advantage which we should exploit. Would you give me your insight into how and to what extent we should exploit this advantage and at what costs to us?

Mr. ALDRIDGE. Yes, sir. Of course the President has supported a commercial ELV industry. We believe that the complementary ELV program that we are pursuing allows that industry to take derivatives of that particular vehicle and compete in the commercial market with it, and we are encouraging them to do that if we can.

There are the Titan 34D or Titan vehicles that have been built for many years. I believe that now we have launched 303 Titan vehicles. Reliability has been outstanding. It is not a piece of paper. It is a true vehicle. I believe that the flight history and flight capability of those vehicles are well known throughout the world, and I believe we ought to be using that type of vehicle to compete with Ariane or any other foreign launch vehicle.

I believe it has better capability. It has proven reliability. And if we can get the cost down to be competitive with the foreign launchers, I believe we ought to exploit that as much as we can.

Senator GORTON. What complications does that have for the shuttle pricing policy?

Mr. ALDRIDGE. Well, the shuttle price policy is, of course a very controversial subject, and there are two types of policies that we have to deal with. One is the pricing policy that NASA charges the Department of Defense or any other Government agency. That is somewhat different than the pricing policy regarding commercial use.

Senator GORTON. At this point my question really relates to the second, the commercial.

Mr. ALDRIDGE. Commercial, yes, sir. Let me step back and see if I can address that thing without getting too controversial. First of all, I believe that the success of our space program is not measured by how many shuttle flights we fly. It is how we use that very unique and fantastic machine to augment our space policy. Whether we fly 24 flights a year or 10 flights a year, I believe our measure ought to be how we use that capability.

However, NASA would like to, once we have it, to make some economic, cost effective benefit from it, and would like to get us up and around 24 flights a year. I believe that pricing policy ought to be established such that NASA's requirements fully utilize the shuttle. We also have Government requirements for which I believe DOD is No. 1, and we have committed to eight flights per year.

NASA and other civil users, I believe, will fill up a significant part of the remaining 10, 12 flights a year, and we ought to establish a pricing policy that allows commercial users to come onto the shuttle to use up the remaining amount. And whatever it takes in pricing policy to do that, I think, is the right answer because in some sense the price of the shuttle, the price of the flight is not necessarily what is going to attract people to the shuttle.

It is the fact that it is unique. It has got manned capability. It can do certain things that no other launcher can use. That should be the basis on how to price the shuttle, not whether or not we compete with Ariane to launch some trivial communications satellite or something, and I believe we just need to think about what we are using the shuttle for and set a price that will fully utilize its capability.

Senator GORTON. Secretary Aldridge, you are certainly very straightforward. That is a clear and, I think, a welcome answer. Thank you.

According to your testimony, you and NASA have mutually agreed to slip the first Vandenberg launch until no earlier than the end of January. How much later than the end of January do you really intend or expect to conduct that first launch? Will it be as late as April, 1986, as one media source has speculated?

Mr. ALDRIDGE. Jess Moore and I have been talking about that just yesterday, as a matter of fact. We have agreed to slip it until March 1986. the reason for that is that NASA has now concluded that they would like for safety reasons and the fact that Vandenberg is a new facility with somewhat different configuration than the Kennedy facility is, to conduct a flight readiness firing of orbiter 103 when it get to the pad.

We plan to deliver 103 to Vandenberg in September, and we will probably do the flight readiness firing in January. That will result in about a 22 day delay in the ability to launch. However, the 22 days moves it into a launch period around the first part of March that conflicts with a launch out of Kennedy and they do not want to launch Vandenberg and Kennedy launches during that same period.

So it looks like we will be toward the middle of March, a date yet to be specified for the initial launch, and that is acceptable to us. Once we get beyond the March-April timeframe, we do start getting concerned about the ability to launch and then turn around and be able to launch again in the September timeframe of 1986 out at Vandenberg.

But the March timeframe is acceptable to us.

Senator GORTON. When you testified before this subcommittee on September 10 of last year on allegations of quality control deficiencies at Vandenberg/shuttle launch complex you said that you had corrected all but 14 of the 60 problems which could be categorized as serious. Where are we on those 14 remaining serious problems and have any new ones arisen?

Mr. ALDRIDGE. They are all behind us. Welds have all been inspected. They have all been tested. There are, as far as we can find, no failures in the welding process. Equipment is delivered. The construction is complete. I guess around 97 percent of the equipment has been delivered to the site.

Senator GORTON. The documentation is all completed?

Mr. ALDRIDGE. Yes, sir; we are just in terrific shape for meeting the initial launch capability date of October 15, 1985. Even though the launch date would slip, we elected not to slip the construction pace, and, of course, we had fixed price contracts to deliver the Vandenberg site.

So rather than going back in and opening up fixed price contracts, renegotiate them, we allowed them to continue on to get the construction completed and get those people off the site in the most effective way possible and at least cost. So we kept pressing on it, and we are doing so for October 15.

Right now we are in the major part of a ground system test where we are looking at the hydrogen and oxygen lines and the high pressure lines, and so far we have had no problems at all.

Of the inspector general report that I mentioned when I was here before, there were several items that they requested we do, mostly dealing with quality control personnel. We have instituted a hiring process. We have 14 of the 15 quality control people now on site. All of the inspector general recommendations have been closed out. So I think we are in very, very good shape at this point in time.

That still does not mean that there may be something sitting in the wings. The skeletons may come up and bite us, but right now we are doing very, very well. We are very pleased with it all. NASA, incidentally, is also quite pleased. They find no problems.

Senator GORTON. Good. Has the Air Force or any other branch of the armed services been able to define anymore clearly than you had 1 year ago any potential space station requirements?

Mr. ALDRIDGE. No, sir; we have not, but we have not stopped searching. As a matter of fact, just last week, I wrote a memorandum to the Vice Chief of Staff of the Air Force asking him to set up a study between the Space Division of the Air Force and the Space Command of the Air Force to continue to look to see if there is something we could do to better define the Air Force role of man in space—Air Force man in space.

We have not found that, we call it, the pearl for the use of man in space at this point, but we have not stopped looking.

Senator GORTON. So that is the extent of your involvement at this point?

Mr. ALDRIDGE. Yes, sir; we are looking over the shoulder of NASA. We have no financial interest at this particular point, although we did in the initial phases of the study. But we have done at this point.

Senator GORTON. Will the international element of the space station program affect this study or any potential Air Force use?

Mr. **Aldridge**. It is hard to say how it will affect. We are concerned that if the Department of Defense is involved in the space station and looking for sensor technology or other technology that would have military application, there may be some restrictions that we would want to place on the operation of the space station that may affect how other countries would look upon the space station.

So we are looking at that, but as to how it might affect it at this point, we are not really sure. We are concerned, but that is as far as we can say at this point.

Senator **Gorton**. Secretary Aldridge, I want to thank you for your candid, straightforward, and helpful testimony, and apologize that I have kept you for so long. But we are not through yet.

Senator Rockefeller.

Senator **Rockefeller**. I will submit my questions for the record, Mr. Chairman, if it is all right.

Senator **Gorton**. Fine. That will be included in the record.

[The statement follows:]

[The following information was subsequently received for the record.]

Statement of Hon. Edward C. Aldridge, Jr., Under Secretary of the Air Force

Mr. Chairman and Members of the Committee: It is a pleasure to be able to share with you the most current status of the Department of Defense involvement in the space transportation system. A number of significant actions have occurred over the past year, and I would like to address each of them. Specifically, I would like to discuss the status of the Vandenberg launch an landing site, the rationale for the complementary expendable launch vehicles [CELV]; our plans for the Titan II intercontintental ballastic missiles; our commitment to the space transportation system; and finally, I would like to share some thoughts with you concerning the emphasis of the Nation's space launch strategy.

First, let me say that a fine example of the cooperation between the Air Force and NASA within the space transportation system development has been the acquisition of the Vandenberg launch and landing site, to provide the Polar launch capability the shuttle system needs. The Air Force has almost completed the construction and testing of the Vandenberg launch and landing site, and we feel we are on track to be able to support launches after 15 October, 1985. That is the date of our initial launch capability—however, the first shuttle mission is not scheduled earlier than 29 January 1986. I will address the schedule in more detail in a moment. To date, we have successfully run the non-flight space shuttle *Enterprise* through its paces in the facilities, culminating with stacking it, an external tank and inert solid rocket boosters on the launch pad. The external tank for the first Vandenberg flight is already on base in storage. Everything is going much better than expected, with no major problems noted, and we are still on schedule.

Next, let me speak specifically about the schedule at Vandenberg. Recently, as a result of NASA concerns about the effect of orbiter tile problems on the remainder of their manifest for this year, and as a result of concerns we had over the completion of testing of our payload for the first Vandenberg flight, Mr. Jesse Moore of NASA and I mutually agreed that it was in the best interest of both agencies to slip the first Vandenberg launch until no earlier than the end of January 1986. However, we will continue to press forward for the initial launch capability date of 15 October, 1985, since to do otherwise would require us to extend several fixed price contracts. Such extensions would increase the cost to the Government. I would like to express my appreciation for the way we were able to work together with NASA in agreeing to this mutually beneficial delay of the first Vandenberg launch.

The CELV, which we have chosen through a competitive process to be the Titan $34D_7$, is a result of defense concerns surrounding a need for more assured access to space. The driving requirement for more assured access to space derives from the ever increasing importance of space assets to our national security. The defense requirement for assured access to space under conditions of peace, crisis, and conflict is a validated and urgent requirement which has been stated unambiguously in several administration policy documents. This need for assured access to space is fully consistent with the July 1982, national space policy, in which the President directed that "Expendable launch vehicle operations shall be continued by the United States Government until the capabilities of the space transportation system are sufficient to meet its needs and obligations. Unique national security considerations may dictate developing special purpose launch capabilities." The requirement for a complementary expendable launch vehicle is the product of many space architecture and launch vehicle studies, as well as the DOD net assessment of the total space operation and space launch posture. The President's national space strategy specifies that DOD must "* * * pursue an improved assured launch capability to satisfy two specific requirements—the need for a launch system complementary to the STS to hedge against unforeseen technical and operational problems, and the need for a launch system suited for operations in crisis situations." To accomplish this, DOD was told to acquire "* * * a limited number of ELV's to complement the STS." The CELV requirement was reiterated by the Secretary of Defense in a 7 February 1984 memo, "Defense Launch Strategy." NASA and DOD agreed to the need for an ELV complement to the STS, which the President formalized in his national security launch strategy of 25 February 1985.

A congressionally requested report prepared by the National Research Council [NRC] strongly endorsed the need for a CELV capability. This report warned that generic failures of the STS could shut down the Nation's launch capability. At the same time, a companion study by the NASA advisory task force expressed concern that "the early elimination of ELV's would leave the United States with neither a backup to the shuttle nor active production lines for space launch vehicles of any kind." Assured access to space has, in summary, been endorsed by the President, every level of the DOD including the Secretary of Defense, the joint NASA/DOD launch vehicle technology study group, and the NRC. A CELV is needed as a hedge against the STS technical and operational problems, and to operate in all crisis and conflict situations short of direct attack on the United States.

To fulfill the Nation's need for a complement to the STS, the Air Force conducted a competition for the design, development and production of a CELV which would be a derivative of today's operational launch systems. The objective of the competition was to provide a timely, low risk, and cost-effective approach which would meet our requirements. Should unforeseen evolutionary weight increases emerge, each of the candidate CELV's would have growth capability to match any reasonable need up to the year 2000.

Two industry competitors responded to the Air Force request for proposal: Martin Marietta Corp. entered with an upgraded version of their very successful Titan series, the Titan III; General Dynamics responded with an improved variant of their proven Atlas space launch vehicle, the Atlas II. NASA entered a space shuttle derivative vehicle, the SRB-X.

In parallel with the competition, NASA suggested another vehicle for consideration—the SDV-1E. This was a heavy lift variant of the shuttle, using most elements of the current shuttle with the exception of the orbiter vehicle. The vehicle had been extensively studied by at least two of the potential CELV competitors, but was not submitted by industry.

As a result of the standard competitive process, the winner was the Martin Marietta Titan 34D$_7$. The Titan derivative was the alternative which best met all requirements and evaluation criteria.

To satisfy DOD the requirements for a complementary space launch system, the Air Force plans to procure ten Titan 34D$_7$'s for launch between 1988 and 1993. These ELV's will complement the shuttle system by having the ability to launch shuttle-size payloads weighing up to 10,000 pounds into geosynchronous orbit. Although this capability is necessary as soon as possible, the most cost effective and efficient procurement plan will lead to an initial launch capability in October 1988, shortly after the last of the Nation's current generation of heavy lift expendable launch vehicles (Titan 34D) has been used. The current direction to meet an October 1988 date is driven by the launch needs of a critical national security payload. Design considerations of that satellite drive the urgent need to begin procurement of the CELV. If that satellite is to be capable of launch on the shuttle or a CELV, we must incorporate the design parameters of the selected launch vehicle into the design of the satellite now.

The CELV program will provide a more assured access to space capability for selected shuttle-size payloads at a launch rate of approximately two per year. This program will meet all known and defined requirements. The candidate payloads for the Titan 34D$_7$ launches weigh less than the 10,000 pound booster capability during the fiscal year 1989-92 timeframe. Even with survivability enhancements, candidate Titan $34D_7$ Payloads should not exceed 10,000 pounds.

While clearly supporting the need for a complementary ELV capability for assured access to space, the appropriations conference committee requested an analysis of the implications of the various CELV alternatives in meeting both short-term and long-term expendable launch vehicle requirements. While cost implications were specifically requested, several other factors must be considered to provide a fully responsive and meaningful analysis of the alternatives. The following provides that analysis.

COMPLEMENTARY CAPABILITY

Before we discuss the relative cost, schedule, performance and growth capabilities of the CELV candidates, we need to evaluate the CELV alternatives on the merits of fulfilling the fundamental need for which they are being developed and procured—to provide a complement to the STS for national security payloads. The requirement to reduce national dependence on a single system for our sole access to space prompted consideration of other means to get our satellites in orbit—not to compete with the STS—but to complement it. The consequences of the loss of an orbiter, or a grounding of the orbiter fleet are part of the planning job the military must do for our national security. No set of machinery is infallible. It the orbiter fleet were to be grounded for just six months in the early 1990's it would take the Nation 2 years at a nearly impossible surge rate of 30 flights per year to catch up. Moreover, if an orbiter were lost, we could never catch up with the remaining capability. The selection of the Titan $34D_7$ gives us a launch vehicle which is completely independent of the shuttle—not because we desire to get off the shuttle, but rather, to reduce the chances that some outage for either launch system will affect national security payloads for any significant period.

A complementary ELV system must satisfy specific requirements to serve as a hedge against unforeseen technical and operational problems of the STS. To optimally meet this need, the DOD requires that the "complement" must be as independent as possible of the STS; it must use few STS common hardware components; it must require as few STS common facilities as possible, and its employment should have minimal impact on other STS users.

The CELV competition involved candidates which clearly fulfill the criteria for a complementary capability. The Titan $34D_7$, for example, is separate and distinct from the shuttle system in almost every aspect. Hardware, launch facilities, control centers, the industrial base, and even the crews used to launch it are independent of the STS. Any space shuttle system problem would have no effect on the launch of such a CELV, and likewise, any problem with the CELV woud have no effect on the shuttle.

Shuttle-derived candidates, such as the SRB-X, and the SDV-1E alternative, clearly did not meet these essential qualities of being complementary and independent. Faced with imminent termination of the Nation's expendable launch vehicle programs, we are in a position where a single point failure in the industrial or operational base supporting the shuttle could preclude our ability to get any systems (commercial, Government, or national security) into space for an indeterminate period.

GROWTH

While the DOD competition for a CELV did not specify growth because there are no defined payload growth requirements, the Congress was concerned that this aspect of the CELV capability be considered. Payload capability of the space shuttle is relatively fixed. Future plans also baseline the performance, and aim the improvements at lowering maintenance, life cycle costs, and turnaround time. As a result, DOD shuttle payloads are restricted to no more than the shuttle maximum capability—about 10,000 pounds to geosynchronous orbit.

If payloads were to exceed the capability of the shuttle, we could launch them on expanded versions of the CELV, but we would lose an essential ingredient in the concept of assured access to space—we would again have no alternative launch system for some of our payloads. The Titan (using the industry example) has several distinct growth increments. These increments provide a range extending from a 10% growth margin over the shuttle capability and foreseeable payload weight to about four times that maximum. In exploring the question of growth, the concensus was reached that all vehicles have the ability to grow; however, no defined needs exist for lift capabilities beyond the shuttle and the baseline CELV—10,000 pounds to geosynchronous orbit. To validate the wisdom of building a complementary capability with large growth potential, a national excursion was generated which assumed that sometime near the year 2000, a lift capability of 150,000 pounds to low Earth orbit (LEO) might potentially be needed. While not a necessity, it was further assumed that this 150,000 pound to LEO vehicle would be derived from the space shuttle to the maximum extent possible.

The question to be answered under this scenario is—assuming there is a need for the far term heavy lifter, what is the overall best route to satisfy that need while also satisfying the near term requirement for a complementary ELV?

Concern over the growth capability of the CELV alternatives was expressed by Congress in the Continuing Resolution Act for this year, and we reviewed all potential payloads to insure that the CELV would adequately meet any planned or reasonable payload growth. All studies conducted to date including NASA, DOD and the strategic defense initiative office, have identified no valid requirements through at least the year 2000 that exceed the capability existing in the STS and the Titan. All the CELV candidates demonstrated sufficient growth capability to satisfy any unforeseen payload needs that might occur between now and the end of the century. The potential needs of the strategic defense initiative, the space station, and any new DOD systems must be carefully defined. Until this is done, we must not commit our scarce resources to a major development program to build a booster which might or might not meet the Nation's needs. If a heavy lifter is ever needed by the Nation, and that need is not a certainty in light of our potential ability to use on-orbit assembly techniques for large structures, then the heavy lift requirement should first be defined. Then the Nation can develop a vehicle derived directly from the STS or use the best alternative technology available. The space shuttle and the CELV will clearly meet the Nation's needs during the next 15 years, while the longer term requirements are being defined.

INDUSTRIAL BASE CONSIDERATIONS

The defense industrial base is the cornerstone of readiness and modernization of our space capabilities, and provides the means for meeting our commitments in terms of crisis and conflict. In large measure, that industrial base derives its strength from the competitive economic environment. To sustain our leadership position in that environment, the strength of our manufacturing and technology must be maintained. This need was recognized by both DOD and NASA in our joint launch vehicle technology study response to the President's national space strategy.

However, until the CELV initiative, the national production of launch vehicles was being phased out.

After 1986 there would have been no further production of NASA or DOD launch vehicles in the United States. This implies the disappearance of U.S. engineering and production know-how and capability. In contrast, the Soviet Union, China, France, and Japan continue to build and exploit expendable launch vehicles.

Once our production lines are closed, a restart will be far more costly and production time considerably longer. In the case of the Titan 34D, subcontractors and vendors are already being terminated in anticipation of production line shutdowns. The normal lead time for the manufacture of an expendable booster is approximately 30 months with an ongoing production base. If one has to start a launch vehicle program from "scratch," the lead time could be 7 to 10 years. Our mutual concern, then, is one of keeping America in the space launch business.

While not a primary consideration in choosing a complement to the shuttle, the advantages of maintaining a robust and competitive industry must be factored into the decision process. Furthermore, the maintenance of the national industrial and technology base has a decided effect on the commercial space launch industry.

COMMERCIALIZATION

The national space strategy approved by the President in August 1984 encourages commercial expendable launch vehicle activities. It sets the policy of the Government to promote competitive opportunities for commercial expendable launch vehicle operations and encourage private sector development activities. It is important to examine the implications of the alternatives in light of their ability to encourage and facilitate commercial expendable launch vehicle operations

Mr. Beggs has pointed out that in the last 15 months, NASA and Ariane each gained five new customers. As a nation, of course, we would have preferred to have gained all 10. The CELV's, though not designed as commercial boosters, could provide a continuing ELV production line to allow the Nation to compete directly with Ariane. We will be able to compete for a larger share of the world's space launch business.

As of December 1984 the French Ariane space launch vehicle had captured more than 20 payloads to be launched between now and the end of 1987. Domestic ELVs represent the same technology as used by Ariane, but have enviably higher demonstrated reliability. This advantage should be exploited. Ariane's success points to the fact that there is a market for vehicles that lack the unique capabilities of the shuttle, but provide schedule flexibility and launch date assurance not always present in the STS Program with high priority DOD and other government users such as NASA themselves, with their tightly constrained planetary launch windows in May 1986.

The largest stumbling block for U.S. commercial ELV's has been price. When U.S. contractors recently bid on commercial launch contracts, they lost to the Ariane on price. They could not find a large enough sales base to bring down the cost. Obviously, economy of scale is critical. Are the current heavy lift ELV's of any benefit to the commercial market? The answer is both "yes" and "no." No commercial market sees the need for a single payload of 10,000 pounds to geosynchronous. The "yes" side depends on economy of scale. If production lines are kept open and provide a business base to hold down costs, U.S. industry could compete with Ariane. Because the commercial payloads have no need for high lift capabilities, without some sort of multiple payload manifesting, the ability to downscale the alternative vehicles is important in the commercialization of launch systems.

While the above by no means implies that the DOD should subsidize industry to enable commercialization, it does say that the fallout of satisfying the DOD requirement could also benefit the Nation as a whole.

SUITABILITY FOR OPERATION IN CRISIS AND CONFLICT

In his national space policy, the President directed that military space systems must be survivable. The Titan $34D_7$ provides a balance to the STS capabilities, and an additional degree of freedom for operation in crisis and conflict unattainable with a manned system.

COSTS

The present cost of the CELV Program is expected to be $1.68 billion (fiscal year 1985 dollars). This cost includes the initial design and engineering, purchase of 10 Centaur upper stages, 10 boosters, launch facility modifications, and the launch costs for all 10 flights. Since the 10 Centaurs would be used on either the shuttle or on the Titans, the actual cost to design, build and launch the 10 Titans is less than $1.2 billion. Another way to look at the costs is that the total additional cost to the taxpayer for the CELV Program is between $250 and $750 million, the range of this estimate depends on the various STS cost assumptions used. We thus achieve high confidence of placing 10 high priority national security satellites into orbit for the additional cost of one or two satellites.

An alternative to buying these ten ELVs might be acquiring a fifth orbiter. However, the purchase of a fifth orbiter does not meet the requirements reflected above concerning assured access to space. Also, the mission model does not yet support such a step, and two flights per year on the CELV's will not make the difference to justify such a purchase. Furthermore, to compare costs directly, it costs $1.6 billion to build the CELV and fly it 10 times. The cost of buying the fifth orbiter and flying it 10 times is more than $3 billion.

The report on the analysis of the ELV alternatives was forwarded to Congress by the Secretary of Defense on February 28, 1985. The following discusses the implementation of conclusions of that report.

A complementary ELV capability to satisfy the requirement for assured access to space on the part of the DOD has been directed by the President and approved by the committee of conference in last year's Continuing Resolution Act. The continuing resolution authorized $5 million to begin the development of the CELV.

We have obligated the $5 million Congress appropriated last year to place Martin Marietta on contract to begin work on the Titan $34D_7$, and have submitted a reprogramming action for the additional $30 million needed in 1985 to hold our launch schedule for fiscal year 1989.

Let me reemphasize that Mr. Beggs and I agreed on this subject and subsequently the President formalized this agreement in his national security launch strategy on 25 February, 1985. As you know, this has been a highly emotional and controversial issue over the past year or so. Let me say that it is an often misunderstood issue. The misunderstanding has been related to a misconception that the CELV was only a "ploy" by the DOD to abandon the shuttle. Nothing could be further from the truth. Over the past several weeks, Jim Beggs and I have been working to alleviate the concerns of both NASA and DOD with regard to the CELV, shuttle and future launch vehicles and have come to an agreement. Let me summarize that agreement:

First, we will work together to ensure the shuttle is a viable operational system heading toward 24 flights/year;

Second, NASA agrees with the need for a complementary ELV to the shuttle, with the Air Force buying 10 vehicles to be launched at 2 per year between 1988–1992. The type of ELV was chosen by the Air Force through a competitive process. We chose, as I said, a Titan derivative, the T-34D_7, as the winner of a competitive procurement.

Third, DOD will commit to at least ⅓ of the available STS flights over the next 10 years. Let me add, that is independent of and in addition to the number of ELV's to be flown during that period.

Fourth, we will develop a pricing policy for STS flights that will give positive incentive for DOD flights on the STS.

Fifth, we will work together on studies of second generation space transportation systems using manned and unmanned systems to meet all user needs.

And finally, any disagreements regarding implementation of this agreement are to be referred to the assistant to the President for national security affairs and subsequently, if necessary, to the President.

Along somewhat different lines, the Air Force is taking another step in the space launch area. We have some defense programs which require small, launch-on-demand satellites to be placed in unique low altitude, high inclination orbits. When the President announced, as part of the strategic modernization program in 1981, his decision to deactivate the Titan II intercontinental ballistic missiles (ICBM's), we initiated a study to determine if there were a cost effective use for these residual national launch assets. The study found that the Titan II had sufficient performance to meet the launch needs of some of these defense payloads, such as the defense meteorological satellite. These payloads are ones which clearly do not effectively or efficiently use the shuttle's capabilities, and which do not lend themselves to routine mixing with other missions. Based on our successful experience with the Atlas ICBM and Thor IRBM conversion to space launch vehicles, we are going to begin refurbishment of the Titan II's which we are currently deactivating from three based in the United States. We plan to convert these missiles into space launch vehicles for low altitude, high inclination missions from the west coast between 1988 to 1995. Employing Titan II's as launch vehicles responsibly uses the prior national investment in these missiles. Rather than pay to scrap them, we will get effective and efficient use from them, much as we have done with the old Atlas and Thor ballistic missiles when they were deactivated. The costs to accomplish this are $65 million for the initial engineering and launch pad conversion, and approximately $15 million per vehicle refurbishment. The total cost to the taxpayer for a Titan II space booster launch will be about $30 million.

This DOD initiative to use these valuable national resources is reflected in the fiscal year 1986 President's budget.

The use of the Titan II instead of a shuttle for such programs makes economic and programmatic sense. For instance, the defense meteorological satellite's unique orbit and launch-on-demand schedule would require a dedicated shuttle launch using less than 10 percent of the shuttle's polar orbit capability. This would be an extremely inefficient and ineffective use of the shuttle manned launch system.

In summary, as a nation, we should have the most versatile and capable launch systems. I believe we have that opportunity facing us today. We must create an environment where the launch capabilities for each of our separate space sectors—civil, commercial, and national security—are complementary rather then competitive. We must foster all three capabilities and use each in its most advantageous application if we are to maintain our national space transportation leadership.

This concludes my remarks, Mr. Chairman. I would be happy to answer any questions you may have at this time.

Questions of Senator Rockefeller and the Answers

MANNED SPACE STATION

Question. DOD is on record as having no perceived need for a manned space station in the foreseeable future.

Is that still DOD's position?

To what extent would the space station be used for DOD research and development activities? Can an "international space station" be used for DOD research?

Answer. The DOD position was, and still is, that we see no militarily useful purpose for the NASA space station. In that position statement, we also explained that we would continue to study the potential utility of military man in space, and possible use of the NASA space station for such things as research and development.

Since taking that position, we have been studying our options as a user in more detail, and are nearly compete with an extensive study concerning the subject. We will be identifying the types of research and development activities which may be done on a space station within the next year.

International participation in the NASA space station causes some security concerns, but these should be possible to work around if the NASA space station is designed acceptably to protect such things as company proprietary manufacturing information and processes. Again, we will be watching the development of the NASA space station to see how they proceed.

FISCAL YEAR 1986 NASA AUTHORIZATION BILL

Question. Public Law 98-361, the FY 1985 NASA Authorization, includes the following language:

SEC. 107. No civil space station authorized under section 101(a)(2) of this title may be used to carry or place in orbit any nuclear weapon on any celestial body, or to station any such weapon in space in any other manner. This civil space station may be used only for peaceful purposes.

Would inclusion of similar language in the FY 1986 NASA Authorization bill be consistent with DOD's perceived needs of the space station?

Answer. Such suggested language is consistent with any potential use of the NASA space station by DOD.

U.S. TECHNOLOGY TRANSFER

Question. There has been much written lately about the potential threat that U.S. technology transfer restrictions pose to the development of an international space station.

What role will DOD play in establishing technology transfer guidelines for the space station? In your opinion, will these guidelines affect the willingness of our international partners to participate in the space station program? In the strategic defense initiative (SDI)?

Answer. We are participating with various other agencies concerned with adverse technology transfer issues in assisting NASA's establishment of appropriate guidelines for the NASA space station. While we are only a potential user of the NASA space station, our experience in the area of technology transfer may help NASA protect against adverse transfer of militarily critical technologies.

ELV BACKUP CAPABILITY

Question. In your testimony, you spend a great deal of time discussing the Air Force decision to purchase 10 complementary expendable launch vehicles (CELVs). However, you don't provide a great deal of background information as to what circumstances changed that caused the Air Force to require an ELV backup capability.

Would you please inform the Committee what circumstances changed that caused the Air Force to shift from total reliance upon the Shuttle to the need for a CELV backup capability?

Doesn't the proposed Titan Centaur ELV share common launch systems and hardware with the Shuttle?

Is the proposed buy of the 10 Titan CELVs a one-time buy? Does the need for a CELV backup disappear in 1992, or is this the first phase of a longer term program? If so, why were each of the candidate CELVs required to "have a growth capability to match any reasonable need up to the year 2000?

Answer. The Department of Defense space systems have become essential elements of the operational systems which provide for our national security. The degree to which we now depend on these space systems for warning, communications, surveillance, weather, navigation and space defense was not clearly evident in the early to mid-seventies when the initiatives for total reliance on the Space Shuttle were being formulated. As the result of almost a decade's knowledge and experience gained since that time, we have seen substantial increases in our reliance on space, changes in the threat, growth in our own and the adversary's space force structures, and we have accumulated a much better understanding of capabilities, limitations, and operation of the Space Transportation System. Paradoxically, with our reliance on space increasing to the extent that critical elements of some of our most vital missions (noteably, warning, surveillance, and communication) can *only* be accomplished from space, we are shutting down our nation's space launch vehicle industry and limiting our access to space to a small fleet of unique Space Shuttle orbiters. A number of studies have been completed to address this dilemma and each recommends the implementation of a Complementary ELV system. Foremost of these is a Congressionally requested report prepared by the National Research Council which strongly endorsed the need for a complementary launch vehicle capability. This report warned that generic failures of the Space Transportation System could shut down the nation's launch capability. At the same time a companion study by the NASA Advisory Task Force expressed concern that "the early elimination of ELVs would leave the U.S. with neither a backup to the Shuttle nor active production lines for space launch vehicles of any kind." Assured access to space has been endorsed by the President, every user of space launch vehicles, the Secretary of Defense, the Chairman of the Joint Chiefs of Staff, the joint NASA/DOD Launch Vehicle Technology Group, and the National Research Council. A CELV is needed as a hedge against STS tehnical and operational problems, and to operate in all crises and conflict situations short of direct attack on the U.S.

The National Space Policy, signed by the President in 1982, states that the Space Transportation System (STS) is the primary U.S. government space launch vehicle, but that unique national security requirements may dictate the development of special-purpose launch capabilities in addition to the STS. It was the National Space Strategy, enacted by the President in August 1984, which directed the DOD to acquire a limited number of ELVs to complement the STS. The combination of these two systems will provide our national security systems an assured launch capability under both peace and conflict conditions.

The Titan 34D7 vehicle chosen to fill the need for a CELV is separate and distinct from the Shuttle in almost evey aspect. Hardware, launch facilities, control centers, the industrial base, and even the crews used to launch the Titan are independent of the STS. Any Space Shuttle problems would have no effect on the launch of the CELV. The upper stage Centaur, although proven in its reliability over the course of 23 years and 70 launches can also be complemented by the Inertial Upper Stage on the CELV. The TOS/AMS although still in a design state, and other designs being worked on by industry, have the potential to provide a stable of upper stage capabilities.

While the proposed acquisition of 10 Titan CELVs is a one-time buy, the President's Launch Strategy of 5 Feb 85 directed that DOD and NASA jointly study the development of a second generation space transportation system making use of manned and unmanned systems to meet the requirements of all users beyond the 1995 time period. As this study progresses and our requirements and capabilities evolve, we will have an insight that can be applied to determine the nature of the follow-on to the Shuttle/ELV complementary architecture.

Although the DOD competition for a CELV did not specify growth because there are no defined payload growth requirements, Congress was concerned that this aspect of the CELV capability be considered and so directed. While the request for CELV proposals did not specify growth capability, each candidate system possessed the ability inherent in its design. The Titan 34D7 selected as the winner of the CELV competition has several distinct growth increments above its basic 10,500 lb to geosynchronous capability.

DOD ELV LAUNCH CAPABILITY

Question. In your statement you argue that maintenance of a "robust and competitive industry must be factored into the CELV decision process."

Didn't the administration consciously support the decision to get the Federal Government, in particular NASA, out of the ELV launch business? Wasn't that decision premised on the emergence of a commercial ELV industry capability? What circumstances have changed? Was a "commercial" ELV option considered by DOD?

Answer. National Security Decision Directive 94 encourages domestic commercial exploitation of space capabilities, technology and services for the U.S. national benefit. Executive Order12465 designated the Department of Transportation (DoT) the lead agency within the Federal Government for ELV activities by the U.S. private sector.

We cannot speak for NASA on their intentions to phase out ELVs. However, the net effect of the President's policy has been the designation of DOT as sponsoring agency for commercial launch customers for our national test ranges.

The National Space Policy, signed by the President in 1982, states that the Space Transportation System (STS) is the primary U.S. government space launch vehicle, but that unique national security requirements may dictate the development of special-purpose launch capabilities in addition to the STS. It was the National Space Strategy, enacted by the President in August 1984, which directed the DOD to acquire a limited number of ELVs to complement the STS. The combination of these two systems will provide our national security systems an assured launch capability under both peace and conflict conditions.

The DOD did, in fact, initially propose a commercial arrangement for financing the CELV program. However, after concerns were raised within Congress and the OMB, the financial plan was revised to that of a more traditional DOD acquisition program.

COST OVERRUN FOR THE CENTAUR PROGRAM

Question. Mr. Beggs appeared before this Committee on February 26th. At that time the Committee was told that NASA and the Air Force would be able to provide a detailed accounting of the Centaur G and G Prime upper stages development program by April 1.

What is your best estimate of the cost overrun for the Centaur program? Is this the final estimate? What share of this overrun will the Air Force pay? What is the breakdown between NASA and DOD of the total development costs including this overrun?

Isn't this upper stage a critical element of DOD's CELV backup vehicle?

Answer: NASA is the lead Centaur G and G Prime development agency under the terms of a NASA/USAF Memorandum of Agreement (MOA). In that capacity, they have provided the following information to the Air Force.

NASA's best estimate of the cost overrun for the Shuttle configured Centaur G and G Prime develoment program is $60-$70 million dollars. The Air Force's share of this overrun will be no more than $19.9 million, since the MOA caps the Air Force's development costs at $150 million.

NASA's breakdown between NASA and DOD of the total development costs are:

[In millions of dollars]

	Fiscal year 1986 budget	Overrun	Total development
NASA	$253.8	$40.1–50.1	$293.9–303.9
DOD	130.1	19.9	150.0
Total	383.9	60–70	443.9–453.9

The Air Force understands that the final estimate of the development program costs for the Shuttle configured Centaur will fall within the range of total development cost shown above. The Air Force also understands that there is a potential cost increase to follow-on production vehicles.

The Centaur G Prime is also the baseline upper stage for the Air Force's CELV program. The CELV upper stages, however, will be procured separately from the present NASA/DOD Centaur development contract. While the Centaur is the primary stage proposed for the CELV, other stages such as the IUS could be used for certain payloads.

FULLY OPERATIONAL AND COST EFFECTIVE SHUTTLE

Question. The recent National Security Launch Strategy directive states "that NASA and DOD will work together to insure that the STS (shuttle) if fully operational and cost effective at a flight rate sufficient to meet justified needs. (The target rate is 24 flights per year)." The directive goes on to say that "DOD will rely on the STS as its primary launch vehicle and will commit to at least one-third of the STS (shuttle) flights available during the next ten years."

In what manner will the Air Force work with NASA to insure a "fully operational" and "cost effective" shuttle? Does this mean additional R&D and hardware development funding will be required?

Answer. To bring the Space Shuttle Program to a "fully operational" condition, the Air Force is activating its share of the Space Transportation System. The modification to the NASA command and control system to support classified Department of Defense missions demonstrated an initial operational capability in January 1985 with the launch of the first dedicated DOD mission.

The Vandenberg launch and landing site on the West Coast will reach Initial Operational Capability (IOC) in October 1985 and be fully operational by 1987. The Inertial Upper Stage has been modified to bring it back into the operational force, and we are funding a share of the Centaur upper stage development which will produce vehicles ready for flight in 1986. These added capabilities will aid in reaching the goal of 24 missions per year and reducing the cost per mission for all users. R&D and hardware development funding to support these capabilities is in current and prior year budgets or programmed by the Air Force.

ONE-THIRD OF THE SHUTTLE MANIFEST

Question. The Committee has been shown an internal Air Force memo that states "the Space Shuttle Main Engine (SSME) has had a disappointing performance" as well as that "the SSME can't be improved with modifications but requires a 'whole new powerhead'." In light of these deficiencies, why did the Air Force commit to one-third of the shuttle manifest?

Answer. The USAF Shuttle Assessment Report, dated October 1984 states that the SSMEs have performed satisfactorily and problems encountered to date "are considered transitory." Of concern to the DOD is the fact that even with filament-wound-case solid rocket boosters and main engines operating at 109% thrust, maximum Shuttle performance from Vandenberg is approximately 4,000 pounds less than the Air Force requirement and NASA commitment of 32,000 pounds lift capability to low earth orbit. However, in spite of these limitations we are aware of an extensive effort by NASA to improve performance to reach their stated performance goals. We are therfore confident that the Shuttle will support the planned mission model, which does not require the maximum performance capability of the Shuttle. In 1988 and beyond, we are planning to fly eight or more missions per year with the Shuttle. That plan was developed prior to the Air Force agreement to utilize at least one-third of the Shuttle missions.

AIR FORCE MISSION MODEL FOR THE SHUTTLE

Question. To what extent does the proposed Air Force mission model for the shuttle of 8 flights/year include SDI R&D flights? Is the SDI shuttle demand yet to be determined and factored into the overall shuttle flight rate?

Why should anybody have any more confidence in this agreement than prior NASA/DOD agreements?

For example, in 1961, NASA and DOD signed an agreement that stated: "It is hereby agreed that neither DOD nor the NASA will initiate the development of a launch vehicle or booster for space without the written acknowledgement of the other agency that such a new development would be deemed consistent with the proper objectives of the National Launch Vehicle Program."

Answer. The DOD Shuttle mission model reflected in the fiscal year 1986 President's Budget Request includes [deleted].

DOD entered into its agreements with NASA in good faith. Historically both DOD and NASA have a good record of complying with such agreements, including recent compliance with the 24-year old agreement cited in the question. In this particular case, not only have DOD and NASA agreed on the development and implementation of a Complementary ELV program, but additionally, the President ratified and directed the elements of this agreement in his February 1985 National Security Launch Strategy.

TRACKING DATA RELAY SATELLITE MISSION

Question. NASA recently indicated that the recently scrapped TDRS mission (Tracking Data Relay Satellite) might not be launched until next year.

To what extent does this delay affect the current DOD space program? Does the anomaly in the current TDRS system pose any national security concerns?

Answer. [Deleted.]

SHUTTLE PRICING POLICY

Question. There has been much publicity about the shuttle pricing policy debate, including reports of your testimony before the House Science and Technology Subcommittee on Space Science and Applications.

Would you please give the Committee DOD's view, and your view if they differ, of the most appropriate shuttle pricing policy for the 1989–91 period? Does shuttle pricing policy present any national security concerns? Is there enough "short-term" demand to support commercial ELVs?

What is the current status of the NASA/DOD negotiations to establish a shuttle pricing policy for DOD? Will the Committee be informed of these results by April 15th?

Answer. The Space Shuttle pricing policy is an issue being addressed by an interagency working group in support of the Cabinet Council on Commerce and Trade; DOD is a participant in this group. It would be inappropriate for DOD to comment except to say that we support a pricing policy which ensures a fully operational and cost effective Space Transportation System, and provides the foundation for a future space launch system architecture to meet the needs of all users. A policy which satisfies these goals will satisfy our national security requirements.

Commercial ELVs are not a topic under the purview of DOD, however, it is evident that the Ariane launch vehicle has found a sufficient commercial market to fill a substantial launch schedule.

A working copy of the NASA input regarding DOD Space Shuttle pricing was submitted to the Air Force on April 19, 1985. We have initiated negotiations on the subject.

REFURBISH TITAN II ICBM'S

Question. There has been much discussion of the recent Air Force decision to refurbish Titan II ICBMs to launch DOD payloads. Based on "preliminary" response submitted for the record of the Beggs Hearing, "NASA's estimate of the cost of launching six Defense Meteorological Satellites and three NOAA Metsats, exclusive of the satellities designed for Shuttle compatibility, is $344 million for Titan II and $225 million for shared Shuttle flights."

What is the Air Force's estimate of the block change costs to make these payloads Shuttle compatible. Why is the Air Force resistant to the use of shared payloads at Vandenberg? Doesn't the use of shared payloads change the "economics" of this debate?

Answer. The Air Force's estimate of the average launch cost of a Defense Meteorological Satellite Program (DMSP) or NOAA satellite on Titan II is approximately $30 million in FY 1985 dollars. This cost would also apply for the Navy Remote Ocean Sensing System (N-ROSS) and the classified Titan II user. The comparable Shuttle cost is $65 million.

The DMSP nonrecurring costs to make the DMSP Block 5D-3 satellites Shuttle compatible is $70 million (FY 1985 $). NOAA should be asked to provide their costs for the record separately.

The Air Force is not resistant to using shared payloads at Vandenberg. However, DMSP's size, unique orbit, launch on demand requirement, and high priority preclude sharing. In fact, extensive modifications to DMSP and NOAA would be required to permit these systems to launch with another DMSP spacecraft. Given funding to maintain a Shuttle launch on demand option, any potential civil shared payloads (most of which have planned East Cost launches) would have to be on call waiting for the DMSP launch. If none were available, the U.S. government would have to be prepared to launch a Shuttle with only the small DMSP onboard if necessary. This is neither efficient nor economical.

DMSP will transition to the Shuttle with the Shuttle *optimized* DMSP II follow-on to the six Titan II launched Block 5D-3 satellites. This is a more efficient and economical approach than redesigning the current expendable launch vehicles optimized satellites for Shuttle compatibility without any of the associated benefits that derive from Shuttle optimization. These benefits, such as the on-orbit repair and retrieval planned for DMSP II, are not possible for the current DMSP design.

REFURBISHMENT OF THE TITAN II VEHICLES

Question. Of the 52 Titan II vehicles deactivated by DOD, how many will be modified for use as expendable launch vehicles? During what time period will these ELV's be used? Does the refurbishment of Titan II vehicles improve the economics of Titan 34D7s (DOD's CELV)?

Between the CELVs and Titan IIs, how many payloads has the Air Force removed from the Shuttle manifest?

Answer. Of the Titan IIs being deactivated, only 13 are planned for use as space launch vehicles between 1988–1996. Of these 13, six are planned for DMSP, six for classified program, and one for the Navy Remote Ocean Sensing Satellite (N-ROSS).

The refurbishment of the Titan IIs is not expected to improve the economics of the CELV, but the converse is anticipated. The Titan II refurbishment should benefit from the larger business base created by the CELV.

Of the 216 Space Shuttle flights available during the period projected to fly the 10 CELVs and 13 Titan IIs, the Air Force will have removed the equivalent of 12 missions from the Shuttle to launch on CELVs and Titan IIs. This is less than one percent of the NASA's launch business. The CELVs comprise 10 missions of the total; the Titan IIs are equivalent to two

ERA OF SPACE COMMERCIALIZATION

Question. There is much said about the ERA of Space Commercialization. However, the verbiage seems to conflict with the realities.

For example, the Air Force will fly three NOAA satellites that could have been flown on a commercial Delta, and OMB has intervened to mix the privatization of Landsat contract.

What steps had DOD taken, in particular the Air Force to promote the procurement of commercial space hardware and/or service?

Answer. The Department of the Air Force fully supports the commercialization of space as noted in the President's National Security Decision Directive 94 and the Commercial Space Launch Act. Although the Department of Transportation is the lead government agency for facilitation of commercial launch activities, as the DOD Executive Agent for Space Launch, we are actively encouraging this new industry. Several regulations have been waived so that commercial operators are not charged nonrecurring costs of Air Force previously developed space launch vehicles, existing tooling and facilities. We are encouraging use of our national test ranges with a direct pricing policy that requires the contractor only pay for services received.

SOLE-SOURCE PROCUREMENT OF THREE INERTIAL UPPER STAGES

Question. Is it true that the Air Force recently decided to make a sole-source procurement of three Inertial Upper Stages? Why wasn't a competitive procurement used in light of the fact that several commercial upper stages now are available? Don't the same "economic" arguments that exist for refurbishing Titan IIs exist for other DOD procurements?

Answer. Over the last six months, the Air Force has worked very hard with the Department of Transportation in establishing a set of guidelines for services to be offered by the Air Force in support of commercial space booster companies. We are pleased to say that these guidelines are fully consistent with the Space Commercialization policy of the President, and cite a variety of waivers to Defense Acquisition Regulations which will allow the Air Force, and DOD, to facilitate the commercialization of space. This landmark guidelines package was recently approved by the Secretary of Defense, and is now being turned into a set of DOD Directives.

The three NOAA satellites you mentioned have grown too heavy in weight for their launch aboard the commercial Delta launcher. Their launch vehicle alternatives were the Shuttle or the Titan II. Since the DOD Defense Meteorological Satellite will launch on the Titan II, and the NOAA satellites are based on the DMSP satellites, the use of a common launch vehicle made sense. However, the weight of these satellites precludes the use of smaller vehicles such as the Delta.

The Air Force decided to make a sole source selection for three Inertical Upper Stages, since competition of the upper stage buy would not have allowed schedules to be met for the launch of those particular satellites. The DOD will be developing an upper stage strategy which will allow competition in the future, so long as schedule or other problems do not preclude it.

CURRENT RACE FOR SPACE

Question. A recent Defense Daily article headline read "Soviets Boosting Space Spending 15% Annually." The article then went on to quote the Air Force and said:

1. by the late 1980s the Soviets will have a heavy-lift booster that can lift payloads five times larger than the maximum U.S. capability;
2. by the mid 1990s, the Soviets probably will have a permanently manned space station which will be used primarily for military purposes;
3. it is clear that the Soviets intend to attain and maintain military superiority in space.

Is this "Air Force" representation an accurate portrayal of the current race for space? How does U.S. space technology compare with Soviet space technology? How does the Soviet space budget compare to the U.S. space budget?

Answer. The portrayal of the Soviet space program does appear essentially correct.

U.S. space technology is superior to that of the Soviets, and will remain so for the foreseeable future.

A direct comparison of budgets between the U.S. and the Soviets is more difficult to put on an equivalent basis. It would appear that the Soviet expenditures may be somewhat higher than the U.S., but whereas the Soviets have central controll of all military and civil space programs, the U.S. has three separate and independent sectors for civil, commercial and national security.

SEVENTH SOVIET SPACE STATION SALYUT

Question. In the late 50s, the U.S., especially DOD, was frantic about Sputnik, but today there is no concern about the fact that the 7th Soviet space station Salyut is on-orbit and has been for over 34 months.

Would you please explain this phenomena to the Committee?

Answer. Between the launching of the first Sputnik and the present day, the U.S. has demonstrated a tremendous technological lead over the Soviets. Our automated systems are extremely efficient and capable, especially in comparison to the similar capabilities of the Soviets. In fact, our present automated space systems would actually be degraded in a variety of ways by man's presence. We continue to explore the potential for military men in space, but we have not yet found a role which would gain sufficiently over other means of accomplishment. Similarly, we are watching the Soviet developments, and consider their developments in our evaluation of the need for the U.S. military man in space.

Senator GORTON. Secretary Aldridge, we have completed our work with you, then. I thank you very much.

Why don't we take about 2 minutes and set this up for the open hearing.

Mr. ALDRIDGE. Yes, sir; thank you, Mr. Chairman.

OPEN SESSION

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to this last of 5 days of hearings of the Subcommittee on Science, Technology, and Space on the fiscal year 1986 NASA authorization. We are here today to consider NASA's aeronautical research and technology programs, as well as our world position in aeronautical technology and sales.

Over the past 69 years NASA and its predecessor, the National Advisory Committee on Aeronautics, have cooperated with private industry in a unique and constructive partnership which has matured to provide this Nation with the world's most advanced aeronautical technology.

Until recently, our Nation's aeronautical technological superiority had enabled our aviation industry to operate in a relatively competition-free environment. This is no longer the case, however. To quote the recently released report by the National Research Council entitled "Competitive Status of the U.S. Civil Aviation Manufacturing Industry, "international competition in aircraft production has crossed a watershed; it has moved from being almost a contradiction in terms to something of a major concern."

To quantify this concern, this report states, one, airbus captured 50 percent of the orders for wide-bodied transports in 1982; two, helicopter imports increased from 14 percent to 35 percent of the civil market from 1979 to 1982; and three, since 1981, the U.S. imported more smaller airplanes than it has exported.

These facts are sobering indicators of the severity of the problem. While technological superiority alone will not reverse this trend, no one can deny the overwhelming significance of a vigorous and farsighted R&D program to the preeminence of our civil aviation industry.

While there had been earlier reports that OMB was considering virtually eliminating NASA's aeronautical research and technology programs as a part of the administration's fiscal year 1986 budget request, it is encouraging to see that at a minimum NASA's fiscal year 1986 budget request for aeronautical research and technology kept pace with inflation which, in this budgetary climate, is not to be taken lightly.

Senator Hollings has an opening statement for the record.

[The statement follows:]

Opening Statement by Senator Hollings

NASA AERONAUTICAL R&D

Mr. Chairman, I want to begin by congratulating you and the other members of the Science, Technology and Space Subcommittee for having successfully concluded your ambitious hearing schedule on the FY 1986 NASA authorization. It has been a long task, but thank to your work and that of Senator Riegle, the subcommittee's Ranking Democrat, you have established a strong record for the Committee to use in pushing for enactment of our bill.

Today's hearing breaks away from the space portion of NASA and focuses on the advanced research and development NASA does for the aviation industry. This is an important area of technology development, and has drawn the focus in recent months of such diverse bodies as the White House and the National Academy of Sciences.

I want to therefore welcome today's expert witnesses on the NASA aeronautical R&D programs. They will hopefully help us better understand this vital area of technology development as well as aid us in working to forge a consensus on the NASA budget.

Senator Gorton. In addressing NASA's aeronautical research and technology budget request and related issues, we are pleased to have with us today Dr. Jack Martin, NASA's Associate Administrator for Aeronautical and Space Technology, together with a panel of aviation industry representatives.

To begin, we will start with Dr. Martin.

STATEMENT OF JOHN J. MARTIN, ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY RAYMOND S. COLLADAY, DEPUTY ASSOCIATE ADMINISTRATOR

Dr. Martin. Thank you, Mr. Chairman.

Senator Gorton: Your entire statement will be included in the record and you may summarize it.

Dr. Martin. Thank you. I will do so in a few minutes. I have with me Dr. Raymond Colladay, who is my deputy. I am here, as you said, to present the budget request for Aeronautical Research and Technology at NASA. The thrust of that budget is to continue the preeminence of U.S. civil and military aviation. We have, we believe, a balanced effort and the statement which you have accepted I think describes that very well.

The budget request for aeronautics is for a total of $354 million. Of that, $239 million is for disciplinary research and technology which is basic and broad-based and long range in nature, and $115 million is for systems technology, which is focused hardware-oriented research with a foreseeable payoff.

Some key elements of the program are the Numerical Aerodynamic Simulation Program, which is the world's most advanced computational system. It is a pathfinder tool for analysis and prediction techniques which will have its initial operating configuration in fiscal year 1986, as I say, during the fiscal year we are talking about. It is, because it is so close to operational capability, very sensitive to funding variances.

Another important element of the program is the Advanced Turboprop Program, which has a potential 20- to 30-percent reduction in fuel consumption operating with the same speeds as the airlines are accustomed, and with equivalent passenger comfort. The program is essentially on schedule for fiscal year 1987 flight test of a single rotation propeller. Equally important, however, is research addressing counter-rotation propellers. There are model tests going on at General Electric and at Hamilton Standard, and these will be a jointly conducted proof-of-concept fan test with GE carried out by NASA. There is a Joint Experimental Aircraft Program which comprises the X-29, the X-wing and the oblique wing. The oblique wing, I might say, is based on the F-8 research aircraft because it has a flexible digital fly-by-wire control system and is very adaptable to the new wing which will be put on it. Studies indicate that civil and military applications in low supersonic speed regimes are possible and of interest.

I might mention also composite research, which we have undertaken to terminate during fiscal year 1986 based on priorities within the program. We believe that of all the key technologies industry is in a better position to continue work on large wing and fuselage composite components, and we believe that the program eventually ought to be redirected to more useful elements. The fundamental research to be conducted is $3.5 million per year.

To conclude, Mr. Chairman, I think the technology opportunities are greater today than they ever have been and that we are ready to exploit them, and we will build on the momentum we have had from previous years. I appreciate your attention and your consideration of our budget and solicit your support.

Senator GORTON. Thank you very much.

Dr. Martin, on Monday the White House science adviser, Dr. Keyworth, released a report that proposed national aeronautical R&T goals related to subsonic, supersonic, and transatmospheric transports. The report says that in the area of subsonic transport all composite primary structures will be brought to maturity in the 1990's.

Is it possible, in your view, to develop this composite technology in support of the subsonic transport goals in spite of the administration's termination of NASA's Advanced Composite Structures Technology Program? Can industry do this?

Mr. MARTIN. Two things are true, Mr. Chairman. First of all, we are not terminating the program in an absolute sense. There is funding from 1985, fiscal year 1985, that we intend to spend in 1985, as we are, and to spend some of it in 1986 to keep that program going.

Senator GORTON. Well, will you then go on and ask for more in 1987?

Mr. MARTIN. We have not gotten to that point yet, sir. It will be based upon some facts which I was just about to say to you. During that period of time, we have undertaken and will carry on an in-house study of what we ought to be doing, but we have asked as well to have the National Research Council Aeronautics and Space Engineering Board to undertake an independent study of the composites and to make their recommendations to us. So that will lay the basis for what request related to composites might be made in 1987.

Senator GORTON. Jim Beggs has stated that if a freeze were imposed on NASA at the fiscal year 1985 appropriations level the Advanced Turboprop Program would be one of the first programs affected. Have you discussed this subject with Mr. Beggs and can you tell us how a reduction in that funding would affect the program?

Dr. MARTIN. We have not spoken in detail, sir. He has said that twice in public—that is to say, before congressional committees—and I have gotten to know him well enough to know he means that.

With respect to how it would be done, it has been kind of iffy up to this point, so we really have not worked the problem in detail as to how we would undertake to do that, but we will if we must.

Senator GORTON. So you cannot tell me whether or not it would affect your schedule in 1987?

Dr. MARTIN. Certainly, yes, sir, it would affect that. I said in the opening remarks that we were essentially on schedule with the funding that we have and have in prospect: But if ATP is cut, I will not even modify it, we would certainly begin to slip back from that calendar year 1987 flight test.

Senator GORTON. With one industry team planning to conduct in 1986 a flight test of its counterrotation turboprop technology, does this in any way reduce the justifications for NASA conducting a flight test of a single rotation configuration after the industry-supported test?

Dr. MARTIN. It depends upon your point of view. I would say that we should continue the program the way we are going now, notwithstanding the test that you mentioned. NASA's responsibilities are to understand in good detail what the elements of a particular technology are and how they work together, and if we carry through a flight test which is not optimized for those research goals, we might well wind up with something which does not in fact demonstrate that the proposition will work, if it does not optimize it in terms of the cabin situations, the noise on the ground, the efficiencies that might come from the operation. So, we believe that NASA should remain in, notwithstanding the flight test that you are talking about.

Senator GORTON. NASA requested $4,700,000 for the oblique wing program, the application of which, particularly in the civil sector, is questionable. In your view, what civil applications are likely to arise in the foreseeable future from the development of this technology?

Dr. MARTIN. First of all, I think on the civil side a business jet might be an application. There has been some interest displayed by

Cessna in that respect. As to larger transports, I think that probably the interest in the large transport industry is mostly very future planning, with the interest that is being taken more of a personal nature rather than a corporate nature.

Senator GORTON. Isn't this primarily a program for the Navy, though, so that they would be taking more than 50 percent of the cost?

Dr. MARTIN. It is difficult to say that. The notion of an oblique wing rose in the 1940's and was a NASA idea that was pointed toward the capabilities which an oblique wing has, which is to fly out to an area and loiter or at least was good for missions that had those characteristics. So fundamentally it is a civil-oriented idea.

It happens to have been picked up by the Navy at this time because of the characteristics.

Senator GORTON. Do you think 50/50 is justifiable, though?

Dr. MARTIN. Historically that has worked best in the past. If you get in cheap, you tend not to give it the attention that it deserves, and so for either one to have a preponderance I do not want to argue that it must be precisely 50/50, but unless it is something near that, there is a tendency, in our experience, to not get as good results as when the funding is near 50/50. So I do not make a case for precisely that, but something of that proportion is the right amount.

Senator GORTON. In testimony which has been submitted to the subcommittee by two of the panel members who will follow you the argument is made that the $28 million requested for 1986 for NASA's Numerical Aerodynamic Simulation Program is excessive and that there is really no critical time for the completion of this program.

I would like your response.

Dr. MARTIN. We have a difference of opinion with that particular opinion, Mr. Chairman. The fact is—well, two facts that are related. First of all, we are 80 percent of the way or more toward an operational capability and now is not the time to get stingy—not that I am attributing that to you, sir. Now is not the time to get stingy with the funding when the return on investment is just around the corner. That is to say, there is so much in it that we might as well complete on schedule and get on with using it.

As to whether there is not a hurry for it, I think what we are trying to do with NAS is to gain and maintain an international leadership. There are sufficient computing capabilities in Europe and efforts being made along these lines that if we falter now we could well wind up not being preeminent in the field and losing the benefits that come from having that leadership position. So I think we ought to continue with that.

Senator GORTON. What are the significant driving forces associated with maintaining, operating and upgrading that program once it has been implemented and what are those ongoing operations likely to cost?

Dr. MARTIN. I would say the main driving force will be the availability of high speed processors, computers which have appreciably more capability, faster capability, or more memory so that what the industry can bring forth is one thing. Another, to a lesser extent, I think, is the algorithms developed for making calculations for the equation which describes fluid flow, which is a very ripe field for endeavor also. So I would say the availability of high speed processors and the development of new algorithms to make efficient computations would be most important.

As to the operating costs, if I might, I will refer to Dr. Colladay, who I think has those figures.

Dr. **Colladay**. Once the initial capability is operational with the current investment, the plan is to maintain that capability at the cutting edge in the hardware modifications and upgrades that Dr. Martin just referred to, and that is included in the budget at $15 million per year in 1984 dollars.

In addition to that, the operations budget for maintaining and operating that capability that is going into AMES right now is on the order of $10 million a year. So the total costs for maintaining and operating at the cutting edge of the computational capability would be about $25 million a year.

Senator **Gorton**. Doctor, I understand that NASA has $5 million in this budget request for planning related to the development of an altitude wind tunnel at Lewis Research Center, a development which would cost as much as $160 million.

What unique capabilities would this wind tunnel provide which do not presently exist in Air Force tunnels and other facilities?

Mr. **Martin**. Two elements, I would say, Mr. Chairman. The first being the capability to carry out near full scale icing research, which is extremely important to us, and especially to the helicopter business. The other capability of the tunnel that, I think, is well worth having is the propulsion integration capabilities it permits in the testing of such configurations as integrated aerodynamics and propulsion at full scale or nearly full scale capability.

So I would say those two aspects—icing research and——

Senator **Gorton**. But they are not available elsewhere.

Dr. **Martin**. Yes, sir.

Senator **Gorton**. To what extent will the size of the test section of this tunnel limit its ability to test large size aircraft propulsion systems, prop fans or rotors for helicopters?

Dr. **Martin**. You would have to get into the details of a specific system to answer with some great precision, but at least half scale would be possible, and with wall suction, which is a possibility, and in fact that is a planned capability, it tends to give a greater capability for an indicated cross section than just the cross section itself would imply. So I think that very nearly full scale, in most cases.

Senator **Gorton**. We all know the significance of the hot section technology program for extending aircraft engine life. I understand that NASA is planning to decrease funding for this program from the $5,200,000 requested in this budget until it is terminated in fiscal year 1990. Does NASA actually intend to terminate the program by the end of the decade?

Dr. **Martin**. Let me just give a short answer to that and then refer to Dr. Colladay, who is the propulsionist by training and experience and very closely associated with that program.

No, we do not intend to terminate that program. In fact, it is presently in the sixth year of an originally planned 5-year program, which is to say we hold it in high regard. As to future possibilities, I will let Dr. Colladay answer.

Dr. COLLADAY. Well, hot section technology will continue to be important to our propulsion program. But, as Dr. Martin pointed out, we have spent, through fiscal year 1986 in the requested budget that we have before you, approximately $40 million in a program that was originally planned for a 5-year effort at $34 million. We recognize the importance of that effort and plan to continue it out through 1989, after which time we will have spent approximately $50 million.

I think that represents and shows the importance that we attach to that area of technology and we will continue to pursue it, maybe in some other manifestation of a future program following on the HOST program, but it is not being terminated. It was planned for completion at that point in time.

Senator GORTON. We have a number of other questions and I suspect members of the minority may also.

We will submit those questions to you and ask you to respond to them in writing.

Dr. MARTIN. Thank you, Mr. Chairman. We will be most responsive.

Senator GORTON. Thank you.

[The statement follows:]

STATEMENT OF DR. JOHN MARTIN, ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Members of the Subcommittee,

The overall thrust of NASA's FY 1986 Aeronautical Research and Technology (R&T) budget request is to advance those aeronautical technologies which are critical to the continued preeminence of U.S. military and civil aviation. It is important to note that most of NASA's aeronautical research has common applicability to both military and civil aircraft. This program will allow NASA to maintain the outstanding aeronautical R&T capabilities represented by the Ames, Langley and Lewis Research Centers. In addition, it will enhance the nation's aeronautical technology base through research in the traditional disciplines and in systems research areas such as advanced turboprop technology and numerical aerodynamic simulation. The proposed program represents a balanced effort in both discipline and systems activities within the constraints of the overall Federal budget.

The FY 1986 NASA Aeronautics R&T budget request is shown in Figure 1, compared with previous year's budgets. The total request for FY 1986 is $354.0M.

The backbone of the nation's aeronautical technologies is in the NASA disciplinary R&T Base programs which are maintained at essentially level funding. These programs, in each of the critical technologies involved in the aeronautical sciences, provide much of the growth and the expanded capabilities necessary for the U.S. to retain its leadership in Aeronautics. The activities in Systems Technology indicate our commitment to advancing the technology in the variety of aeronautical systems of interest to the nation. Special emphasis is being placed on the Advanced Turboprop Technology and the Numerical Aerodynamic Simulator at this time in order to realize major advances in these critical areas. Although the systems technology line reflects an overall decrease, this is due primarily to the termination of the advanced composite structures technology program and a stretchout of the hot section technology program. Funding for the Advanced Turboprop and Oblique Wing programs has been increased.

In addition to experienced researchers and funding to support their activities, an integral and enabling component of NASA's aeronautical research and technology program is the Agency's research facilities. They are national assets which are central to the future development of superior U.S. aircraft.

Examples of major new facility capabilities are shown in Figure 2. (1) the National Transonic Facility (NTF) has demonstrated performance capability over its entire operating envelope, and research testing is beginning; (2) the 40x80x120 foot Low-Speed Wind Tunnel is planned to have its 40x80 foot circuit in operation in the spring of 1986 and the 80x120 foot test section in operation by late 1987; and (3) the Numerical Aerodynamic Simulation (NAS) Facility.

The Numerical Aerodynamic Simulation (NAS) Program, which will provide the most advanced computational system in the world for aeronautical research and development, is a central part of the Agency's Aeronautics program (Figure 3). The NAS capabilities will enable the U.S. to maintain leadership in the aeronautical sciences by providing a pathfinder tool for the development of new, advanced analysis and predictive techniques for aerodynamics research, preliminary aircraft concept developments, and configuration/design refinement.

The initial NAS workstations have already been delivered, installed and are undergoing checkout by computational aerodynamics researchers. The Long Haul Communications System (LHCS) will undergo a user test beginning in late FY 1985. With the delivery of the Cray 2 supercomputer in September 1985, the NAS will have all the major pieces of its initial system in place. In FY 1986, NAS will achieve limited initial operating capability, providing 256 million words of memory and a sustained operating speed in excess of 250 million floating point operations per second to tackle the most demanding aerodynamics computations ever.

The NAS program is extremely sensitive to funding variances. If the program does not proceed at the proposed level, the immediate impact will be to delay the Initial Operating Configuration, force renegotiation of contracts and increase the total expenditure for this capability. In addition, the remote access system would be sacrificed with the result that we would have a world class capability which no one outside of Ames Research Center could use. These delays would adversely affect our developing national research capability in a number of areas including a newly emerging computational aerothermodynamics capability for hypersonics and transatmospheric vehicles and computational fluid dynamics.

Moving now to the topic of Structures and Materials; due to budgetary constraints, a decision has been made to terminate the Advanced Composite Structures Technology (ACST) program. This action is not intended to indicate that fundamental research in composite materials will be terminated by NASA. In making this decision, recognition was taken of the previously significant investments by NASA ($160M) in composite structures and the fact that of all the key technologies for transport aircraft, the industry is in a better position to apply these previously developed structures technologies and continue pursuit of the technology for large wing and fuselage components. Fundamental composites research will be continued at a level of about $3.5M per year. The $19M in FY 85 will be spread over two years to finish the highest priority elements. During that time, we intend to work with the industry to define what effort should be pursued in the future. We are currently considering advanced, lightweight structural materials in general including composites, thermoplastics, advanced metallics, and metal matrix composites as part of any future effort. The combination of future NASA efforts and industry investment will determine the time-frame for any commercial application.

NASA is conducting a broad based propulsion research and technology program in partnership with industry to develop both single- and counter-rotation propeller, drive system and related aircraft technologies for a new generation of fuel efficient civil and military aircraft. Until these technologies are more thoroughly evaluated, it is not clear which will yield the most efficient configuration. Advanced turboprop technology offers the potential for a 20-30 percent reduction in aircraft fuel consumption while maintaining the jet speed and cabin environment of modern turbofan powered aircraft. All elements of the NASA Advanced Turboprop (ATP) program are now in place (Figure 4) to address on a broad front the key technologies which will be available by the late 1980's. Continuing activities initiated in FY 1984 include a proof-of-concept test of the General Electric Unducted Fan (a gearless, counter-rotation propulsion system), the Propfan Test Assessment (PTA) program under contract with Lockheed-Georgia to flight test a 9 foot diameter single-rotation propeller in 1987, and large scale gearbox technology programs with Pratt & Whitney and Allison Gas Turbine of General Motors.

The ATP program plan shown in Figure 5 is proceeding essentially on schedule. The planned FY 1987 flight test of a large-scale, single-rotation propeller is addressing the remaining critical technology issues of structural integrity and acoustics which cannot be adequately verified in small-scale model testing. These technical issues are equally applicable to both single- and counter-rotation configurations and must be resolved before industry can carry these concepts to an operational status. This flight test data will also be used to provide the scaling verification for analytical predictive techniques which are applicable to all ATP configurations and aircraft installations. Only one half of the NASA ATP program in FY 1986 is dedicated to the flight test activity. As mentioned above, the NASA program is also addressing counter-rotation propeller technology through a series of model tests at General Electric and Hamilton Standard, as well as a jointly funded cooperative effort on the large-scale Unducted Fan (UDF) proof-of-concept test. NASA and General Electric are also negotiating the use of Government-owned F404 engines for the referenced industry counter-rotation flight test. In return, NASA would receive access to the data acquired during the tests.

A major program in flight systems research was the NASA/FAA remotely piloted full-scale transport Controlled Impact Demonstration (CID) illustrated in Figure 6. The purpose was to demonstrate and validate technology to improve transport aircraft passenger crash survivability. The aircraft is shown approaching at 146 knots in the top right, impact at the center with the post crash fire at lower left. This flight demonstration of anti-misting kerosene fuel, the major FAA experiment, also included characterization of fuselage and seat response at and following impact. Full scale instrumented fuselage sections were drop tested and results were compared with analytical models. Full scale complex fuselage/wing structural models were also developed for the CID aircraft (Boeing 720). High quality data were obtained during the CID impact test, and comparisons with models and analysis of test results are now underway. The results are being used by FAA in decisions for rule making and by NASA for validation of structural impact dynamic prediction models.

NASA is conducting several experimental aircraft programs. Two of the programs presented here are with the Defense Advanced Research Projects Agency (DARPA), and one is with the Navy.

The NASA/DARPA X-29A Forward-Swept Wing (FSW) aircraft shown in Figure 7, has begun the baseline flight program. The X-29A, in addition to the forward-swept wing, incorporates an array of advanced technologies including a closely coupled canard, flight crucial digital controls, negative static stability, and three surface longitudinal control. All have been integrated to provide a technologically superior, agile and maneuverable aircraft. In FY 1986, the X-29A aircraft will complete its flight research program to fully evaluate the technologies designed into the aircraft.

The joint DARPA/NASA RSRA/X-Wing program is continuing with modifications of the Rotor Systems Research Aircraft (RSRA) and fabrication of the X-Wing rotor system. The X-Wing is a four-bladed, extremely rigid rotor capable of being stopped and started in flight. The X-Wing offers the potential of helicopter hover efficiency combined with the high speed cruise capability of modern fixed-wing aircraft. An artist's concept of the test configuration is shown in Figure 8. Reliability and operational testing of the flight control system and other components is being conducted. The RSRA/X-Wing will continue modification and system tests in preparation for the flight test program starting in late FY 1986.

The preliminary design of an oblique wing research aircraft, illustrated at the top of Figure 9, is being initiated. This joint program with the Navy will develop an experimental aircraft for an FY 1989 flight program that will extend oblique wing technology to transonic and supersonic speeds. The oblique wing research aircraft is intended to be a flight research tool to explore under high speed maneuvering flight conditions the complex interactions of the combined aerodynamic and aeroelastic wing/aircraft dynamics. These complex dynamic interactions can only be replicated in the actual environment of flight. Wind tunnels can provide the performance characteristics necessary for design, but can not replicate the time varying aeroelastic behavior of the aircraft system in maneuvering flight. The F-8 research aircraft (Figure 10), was selected as the test bed because of its existing flexible digital flight control system, its simple adaptability for a new wing, and the availability of necessary ground support facilities. The aerodynamic advantage of oblique wing concepts over conventional swept wing configurations is shown on the lower left. The loiter/dash superiority of the oblique wing over fleet operational aircraft is shown in the lower right. This program builds on a significant technology base which NASA initiated in 1945 and has application to civil as well as military aircraft. Several configuration studies of commercial transports with a low-supersonic-speed capability resulted in oblique wing aircraft designs with lower gross weight than airplanes based on conventional fixed wing or variable sweep wing technology.

The summary presented today contains the highlights of NASA's proposed FY 1986 aeronautics program. Today the technology opportunities in aeronautics are probably greater than at any other time in our lifetime. NASA is committed to playing a central role in the technology development required for superior U.S. civil and military aircraft in recognition that key elements of our national and economic security are linked to preeminence in aeronautics. This FY 1986 budget request builds positively on the momentum that has been generated with your support in the past and, with your continued support, we can move effectively towards realizing many of these exciting capabilities.

Thank you Mr. Chairman.

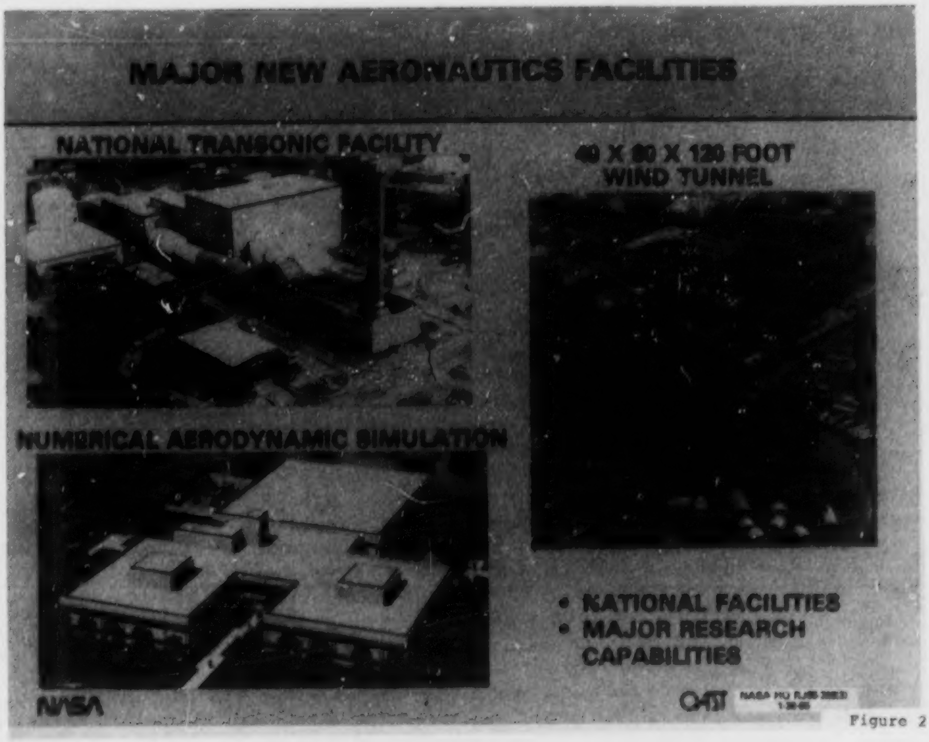
AERONAUTICS RESEARCH AND TECHNOLOGY

R&T BUDGET

	PRIOR	FY 84	FY 85	FY 86
OAST TOTAL (Excl. Standards & Practices)		447.7	487.5	514.0
AERONAUTICS RESEARCH & TECHNOLOGY		315.3	342.4	354.0
RESEARCH AND TECHNOLOGY BASE		228.5	223.3	239.3
FLUID & THERMAL PHYSICS R&T		43.4	44.0	48.5
APPLIED AERODYNAMICS R&T		42.3	42.0	43.7
MATERIALS & STRUCTURES R&T		23.9	27.8	28.0
PROPULSION & POWER R&T		23.5	28.7	31.0
INFORMATION SCIENCES R&T		35.0*	21.1	22.5
CONTROLS & GUIDANCE R&T		19.6	20.5	22.1
HUMAN FACTORS R&T		19.4	20.3	22.0
FLIGHT SYSTEMS R&T		17.5	16.3	18.3
SYSTEMS ANALYSIS		3.9	2.6	3.2
SYSTEMS TECHNOLOGY PROGRAMS		86.8	119.1	114.7
ROTORCRAFT SYSTEMS TECHNOLOGY		27.9	26.0	20.5
GUIDANCE & NAVIGATION	17.4	1.6	-	-
RSRA FLIGHT RESEARCH/ROTORS	32.9	3.3	-	-
ADVANCED ROTORCRAFT TECHNOLOGY	35.8	14.7	9.7	2.7
TECH. FOR NEXT GENERATION ROTORCRAFT	-	8.3	16.3	17.8
HIGH-PERFORMANCE AIRCRAFT SYSTEMS TECH.		19.9	21.5	21.0
HIGH-PERFORMANCE FLIGHT RESEARCH	21.5	8.7	9.7	9.0
TURBINE ENGINE HOT SECTION TECH.	14.0	11.2	9.3	5.2
CERAMICS FOR TURBINE ENGINES	-	-	2.5	2.1
OBLIQUE WING TECHNOLOGY	-	-	-	4.7
SUBSONIC AIRCRAFT SYSTEMS TECH.		5.0	19.0	-
ADVANCED COMPOSITE STRUCTURES TECH.	-	5.0	19.0	-
ADVANCED PROPULSION SYSTEMS TECH.		17.0	26.1	44.2
ADVANCED TURBOPROP SYSTEMS	36.3	15.0	24.0	42.0
GENERAL AVIATION/COMMUTER ENG. TECH.	3.0	2.0	2.1	2.2
NUMERICAL AERODYNAMIC SIMULATION		17.0	26.5	28.2
NUMERICAL AERODYNAMIC SIMULATION	-	17.0	26.5	28.2

*INCLUDES 13.0 FOR CRAY COMPUTER REPLACEMENT @ LeRC

Figure 1



MAJOR NEW AERONAUTICS FACILITIES

NATIONAL TRANSONIC FACILITY

40 X 80 X 120 FOOT WIND TUNNEL

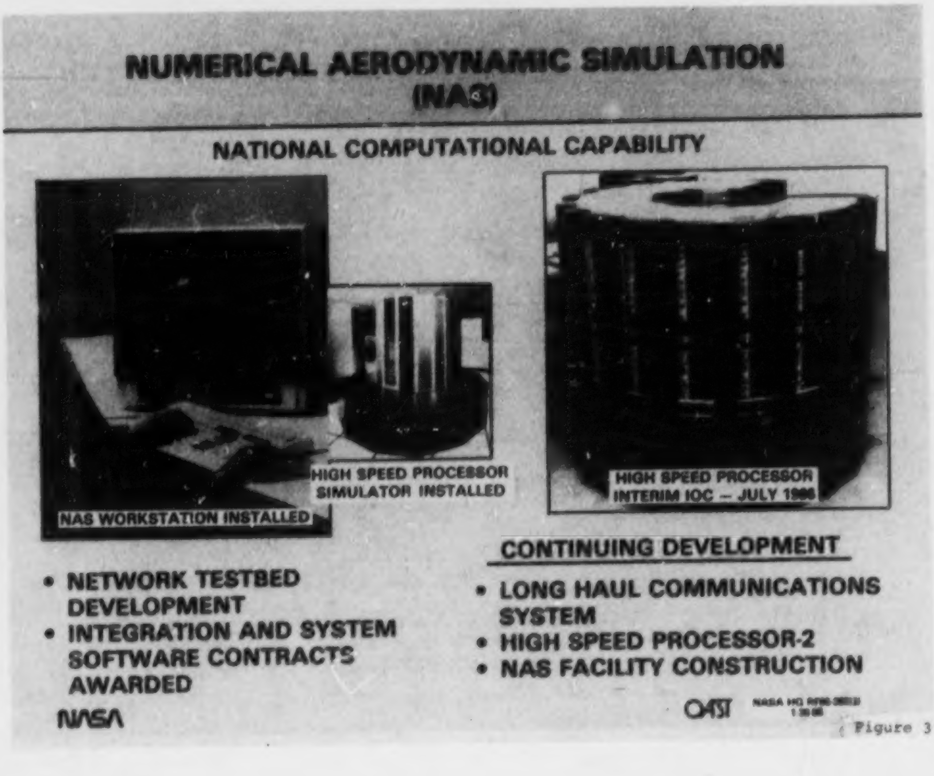
NUMERICAL AERODYNAMIC SIMULATION

- NATIONAL FACILITIES
- MAJOR RESEARCH CAPABILITIES

NASA

OAST

Figure 2



NUMERICAL AERODYNAMIC SIMULATION (NAS)

NATIONAL COMPUTATIONAL CAPABILITY

NAS WORKSTATION INSTALLED

HIGH SPEED PROCESSOR SIMULATOR INSTALLED

HIGH SPEED PROCESSOR INTERIM IOC — JULY 1986

- NETWORK TESTBED DEVELOPMENT
- INTEGRATION AND SYSTEM SOFTWARE CONTRACTS AWARDED

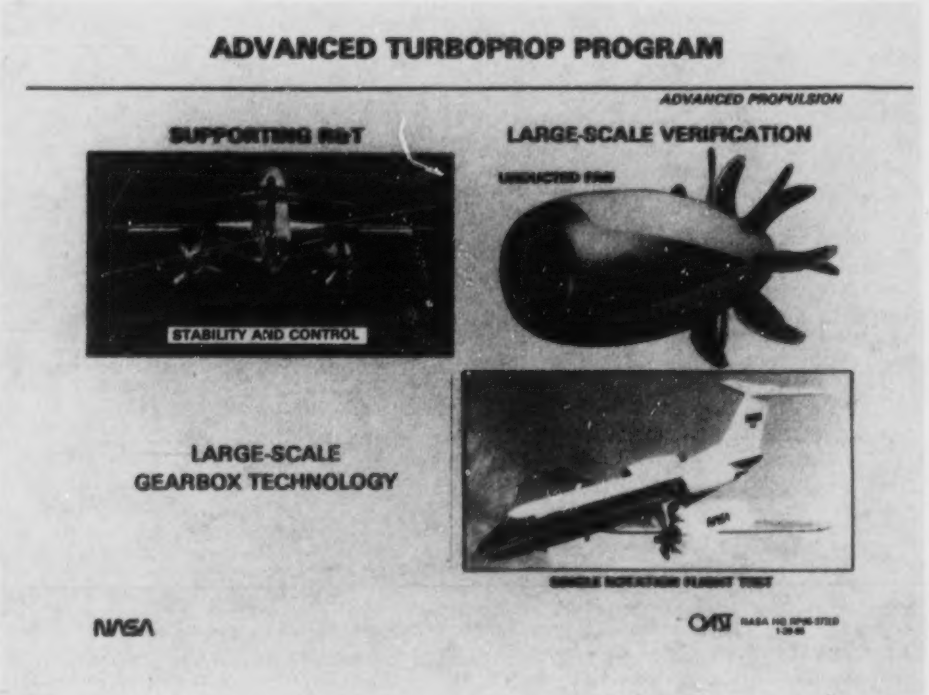
CONTINUING DEVELOPMENT

- LONG HAUL COMMUNICATIONS SYSTEM
- HIGH SPEED PROCESSOR-2
- NAS FACILITY CONSTRUCTION

NASA

OAST

Figure 3



ADVANCED TURBOPROP PROGRAM

ADVANCED PROPULSION

SUPPORTING R&T

STABILITY AND CONTROL

LARGE-SCALE VERIFICATION

UNDUCTED FAN

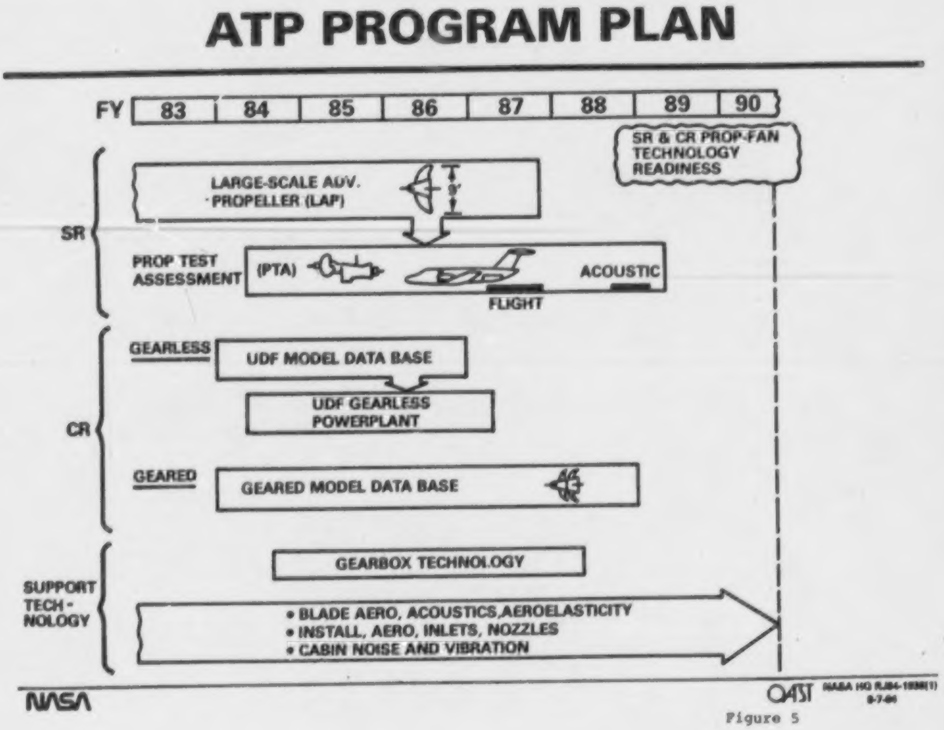
LARGE-SCALE GEARBOX TECHNOLOGY

SINGLE ROTATION FLIGHT TEST

NASA

OAST

Figure 4



ATP PROGRAM PLAN

FY 83 84 85 86 87 88 89 90

SR & CR PROP-FAN TECHNOLOGY READINESS

SR

LARGE-SCALE ADV. PROPELLER (LAP)

PROP TEST ASSESSMENT (PTA) FLIGHT ACOUSTIC

CR

GEARLESS

UDF MODEL DATA BASE

UDF GEARLESS POWERPLANT

GEARED

GEARED MODEL DATA BASE

SUPPORT TECHNOLOGY

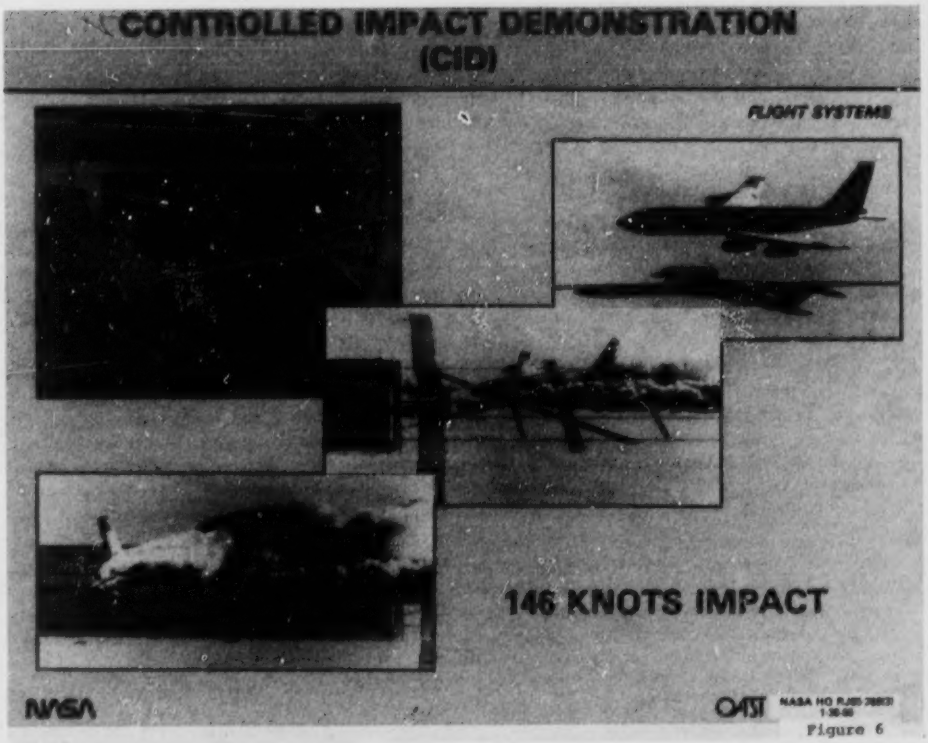
GEARBOX TECHNOLOGY

- BLADE AERO, ACOUSTICS,AEROELASTICITY
- INSTALL, AERO, INLETS, NOZZLES
- CABIN NOISE AND VIBRATION

NASA

OAST

Figure 5



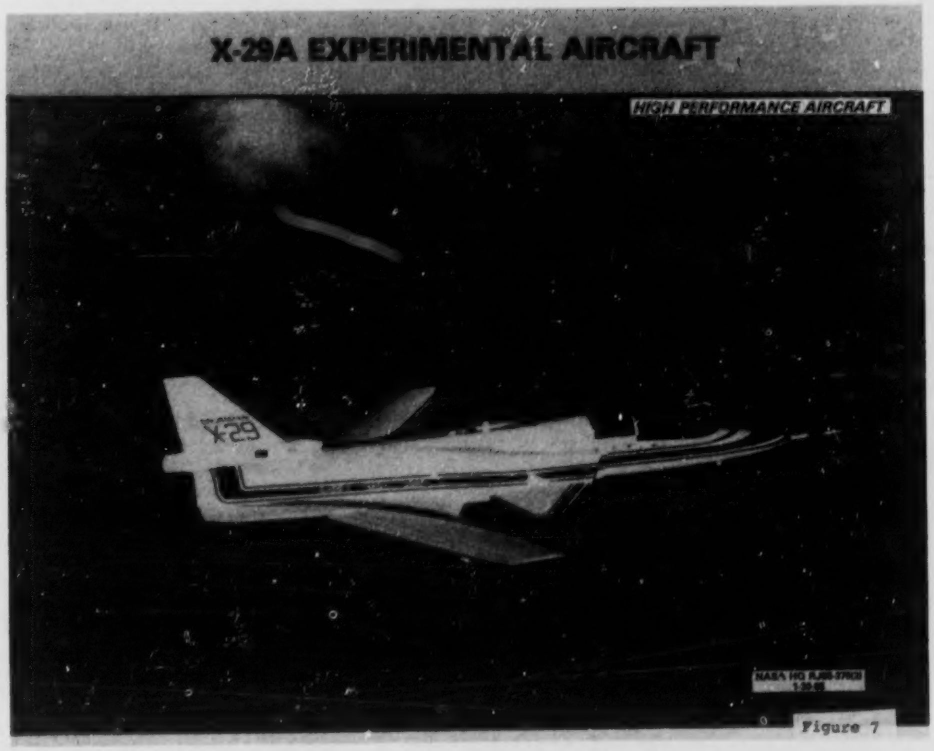
CONTROLLED IMPACT DEMONSTRATION (CID)

FLIGHT SYSTEMS

146 KNOTS IMPACT

NASA
OAST
NASA HQ [illegible]
1-30-86

Figure 6

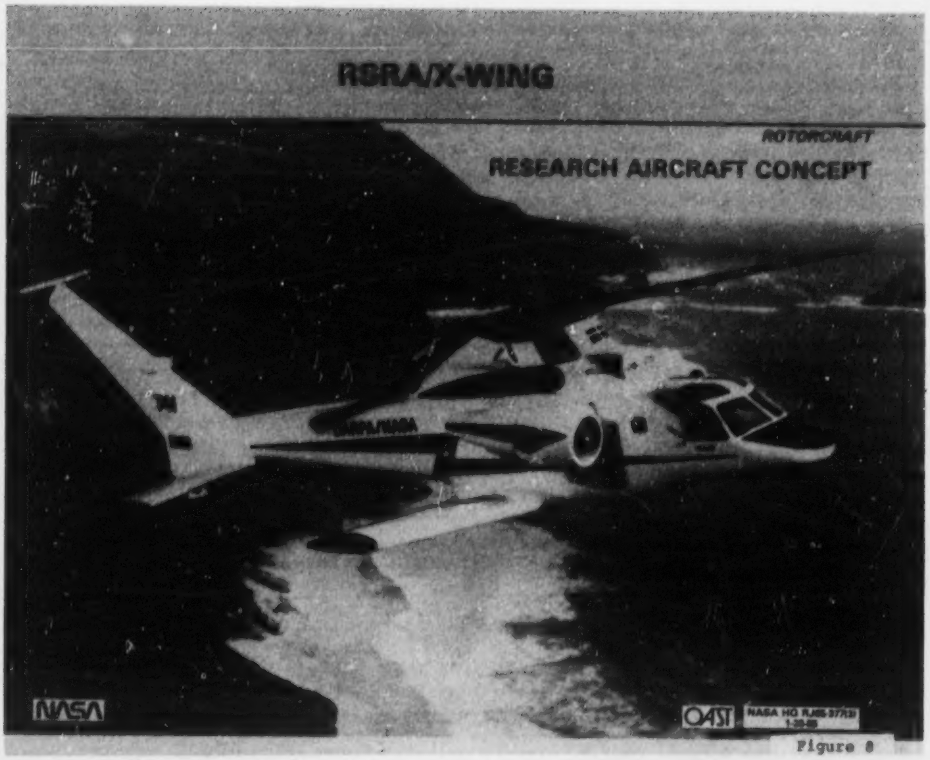


X-29A EXPERIMENTAL AIRCRAFT

HIGH PERFORMANCE AIRCRAFT

X-29
NASA HQ [illegible]
1-30-86

Figure 7



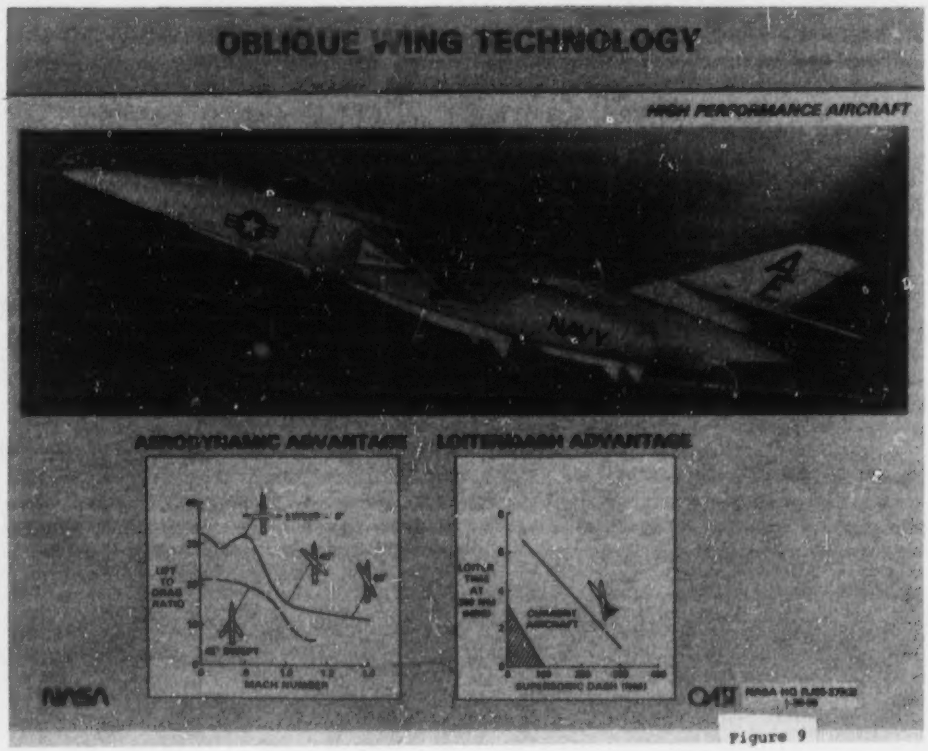
RSRA/X-WING

ROTORCRAFT

RESEARCH AIRCRAFT CONCEPT

DARPA/NASA
NASA
OAST

Figure 8



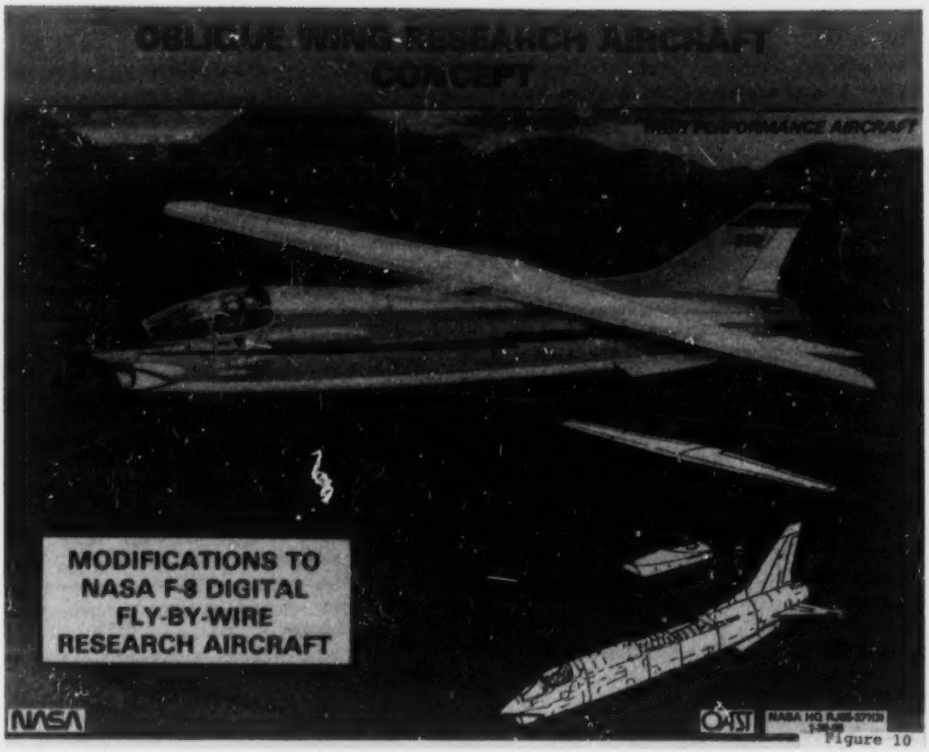
OBLIQUE WING TECHNOLOGY

HIGH PERFORMANCE AIRCRAFT

AERODYNAMIC ADVANTAGE

LOITER/DASH ADVANTAGE

Figure 9



OBLIQUE WING RESEARCH AIRCRAFT CONCEPT

HIGH PERFORMANCE AIRCRAFT

MODIFICATIONS TO
NASA F-8 DIGITAL
FLY-BY-WIRE
RESEARCH AIRCRAFT

NASA

OAST

NASA HQ [illegible]

Figure 10

The following information was subsequently received for the record:

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Proposed National Goals for Aeronautical R&D

Question 1: The second national aeronautical R&D goal of the recently-released report by the Office of Science and Technology Policy relates to supersonic transport. Dr. Keyworth said that, although the Administration has made no commitment to such an aircraft, it is laying the groundwork at NASA and at the Department of Defense. How soon would we be able to respond to a call for a supersonic transport aircraft and at what cost to NASA and the DOD? How and to what extent does NASA's budget request support the fundamental technologies related to supersonic aeronautics?

Answer 1: It is NASA's view that a supersonic transport aircraft technology program might be initiated by building on a base established from 1972 through 1981 in the NASA Supersonic Cruise Research program. Such an effort would emphasize research in more advanced materials, propulsion systems, and supersonic laminar flow and could lead to a technology readiness point in about five years at a cost of $250M. Development (industry's role) could then proceed from this point emphasizing engine, airframe and system development for a prototype phase which could cost in excess of several billion dollars. NASA's budget request for FY 1986 did not include funds to expand research activities directly applicable to supersonic transport/supersonic cruise type aircraft. The National Goals set forth by Dr. Keyworth in April 1985 will serve to focus additional R&T activities on this important class of aircraft in the future. At the present time, about $3 million per year of the estimated $88 million of NASA research applicable to high performance aircraft is directly applicable to supersonic transports, however, significiant synergism exists with baseline flight controls and engine hot section technology (HOST) programs.

Question 2: Concerning the goal of transatmospheric aeronautics, how soon do you envision a national requirement for such a capability? How and to what extent does NASA's budget request support these fundamental technologies?

Answer 2: A national requirement for transatmospherics aeronautics will probably occur when a technology base is sufficiently established to permit the design of prototype or research vehicles capable of continuous hypersonic flight within the atmosphere. Applications of such technology range from single stage to orbit systems to military reconnaissance to space rescue vehicles. The technologies involved include supersonic combustion ramjets, dual or hybrid airbreathing engines, high temperature structures, reentry speed aerothermodynamics and the integration of these into configurations capable of atmospheric flight. NASA Aeronautics and Space Research budgets for FY 1986 include a total of $17.9M of R&D funds ($5.6M Aeronautics, $12.3M Space) to continue technology base activities relevant to transatmospheric flight.

Question 3: When asked if the Administration's new goals in aeronautical R&D would require an increase in NASA's aeronautical budget, Dr. Keyworth said that he did not foresee the need for an increase to support these goals. Can we realistically expect to achieve these goals without any significant increase in NASA's aeronautical budget? How can we accomplish these national objectives within NASA aeronautical budget that grows only at a rate to keep pace with inflation?

Answer 3: The national aeronautical goals announced by Dr. Keyworth clearly represent a challenge to the entire aeronautics community and call on both public and private sectors to engage in a national effort toward achievement of these goals. The purpose is to establish priorities and focus the direction for U.S. aeronautical R&D in key, high-leverage areas that will sustain U.S. leadership into the next century.

The goals and associated research and technology development programs are time-phased in attainment. Though work will be proceeding concurrently on all three goals, each is in a different stage of technology evolution which should spread the impacts of the higher cost technology verification phases.

NASA has recently been asked by Dr. Keyworth to take the lead in developing national "Technology Roadmaps" for achieving these goals. These roadmaps will identify the critical technology elements which need to be emphasized, the estimated costs, and will layout the most effective approach to achieving overall technology readiness. This effort will be an important step in structuring a NASA research program to fully meet the challenges inherent in these national goals.

In addition, we will be working closely with the industry and DoD to develop cooperative programs in these goal areas. This would accelerate advancement by leveraging NASA's research dollars. We also believe that NASA's aeronautics program in these areas will be important in providing leadership for the type of aggressive national research and technology development necessary to secure these high-payoff opportunities in a timely fashion.

Rotorcraft Systems Technology Programs

Question 4: According to NASA's budget projections, NASA intends to terminate its Rotorcraft Systems Technology programs by FY 1988. What is the justification for this action -- will there no longer be an appropriate R&D role for NASA after FY 1987? It appears that the market share of our foreign competition is growing year by year — is this simply a trade issue?

Answer 4: NASA's Rotorcraft Systems Technology program is proceeding according to previously established technical plans and approved budgets. The Systems Technology program elements, by definition, have a specific beginning and end date as well as a fixed funding profile. The reason for the apparent decline in funding is the planned completion of approved programs in the absence of the initiation of new focused systems technology efforts. Proposals for appropriate follow-on efforts in FY 1987 and beyond are being studied in our current planning cycle. NASA plans to continue to address key rotorcraft technology needs in the R&T Base program. The R&T Base funding level planned for FY 1986 is approximately $30 million.

The world helicopter market potential has stimulated strong competition between free world helicopter manufacturers. Foreign competition (from Europe and Japan especially) have been moving aggressively to supply the world markets and have scored successes in the United States - the Aerospatiale HH-65A Dolphin Coast Guard search and rescue helicopter; the Westland 30 commuter helicopter; the MBB BK-117 in the emergency medical serve configuration. In this competitive situation there is a high payoff in the application of advanced technologies.

NASA is committed to maintaining a viable, effective rotorcraft technology research effort within its budgetary constraints to assist the rotorcraft industry in maintaining its technological preeminence.

Question 5: Year after year, Congress and presumably NASA is faced with the question of deciding at what point NASA should no longer conduct certain work and industry should assume the responsibility.

We all know that this decision is based on assessments of risks, lead-time of payoffs, and facilities, but could you expand on this and share with us just how this decision is made?

Answer 5: The OSTP policy for aeronautical research and technology, announced in November 1982, established a framework of government and industry roles, and reaffirmed NASA's central R&T responsibility in this highly successful U.S. aeronautics partnership. In accordance with this policy, NASA conducts aeronautical R&T development with primary emphasis on long-term, high-risk efforts that have potential application to both civil and military aircraft. The R&T development phase proceeds through the validation of technology and consists of activities ranging from theoretical analysis to laboratory investigations to large-scale ground tests and flight testing of experimental aircraft. The subsequent step of technology demonstration is conducted as necessary for military applications, and usually in conjunction with the DoD.

The most difficult and hence most controversial decisions arise when R&T development programs become more applied in nature, and careful distinctions are necessary for NASA to avoid conducting efforts that are more properly done by the private sector. These distinctions are not usually important in large-scale, defense-oriented programs because of NASA's clear role to support the DoD. The criteria NASA uses to assess programs in this category include: (1) the expected payoffs; (2) significant technical barriers and unanswered questions regarding the feasibility of a concept; (3) uncertainties regarding scale effects or interactions among components; (4) the state of the specific technology in industry; (5) whether NASA's contribution will make a difference; (6) unique NASA facilities and expertise; and (7) NASA support required by other government agencies such as the FAA. These factors are all considered in establishing budget priorities. In addition, NASA assesses whether the benefits of the R&T can be captured by an individual firm in terms of rapid commercialization possibilities. If large disincentives exist for private sector investment, the case for NASA involvement is strengthened. Where aeronautical R&T is effectively appropriable, and clearly has predominantly civil application, funds to support this R&T should come from the private sector in the absence of an overriding national need.

National Research Council Report on Competitive Status of U.S. Civil Aviation Manufacturing Industry

Question 6: The National Research Council report suggests that it would be in the best interests of NASA and the U.S. aircraft manufacturers to assign a higher priority to the collection and evaluation of foreign technology. To what extent are we presently taking advantage of the available data of our competition? How can we improve our efforts in this area?

Answer 6: NASA recognizes the importance of up-to-date knowledge of foreign technology capability in maintaining our leadership in aeronautics. NASA and industry participate in many technical exchange forums, such as AGARD (NATO) and international professional organizations (AIAA, ASME, etc.). In these forums, we take active measures to assure "quid pro quo" in the exchange of technology and knowledge. NASA also encourages technical personnel traveling abroad to visit their counterparts and associated industrial organizations in order to stay abreast of the state of technology in the allied countries. The findings of these visits are published in trip reports which are distributed to appropriate personnel in industry and NASA to promote greater awareness of non-U.S. capability.

In addition to the less formal means of acquiring knowledge, NASA has joint and cooperative programs in place for many of the basic aeronautical technologies. At present joint programs exist with the British Royal Aeronautical Establishment (RAE), the French Office National d'Etudes et de Recherches Aerospatiales (ONERA), and the German Deutsche Forschungs-und Versuchsanstalt fur Luft-und Raumfahrt (DFVLR). Additionally, U.S. Army and Air Force technology exchange programs with NATO countries often have significant NASA involvement.

In terms of improving the situation, we should more effectively use the information available through the established exchange mechanisms mentioned above. In addition, there are significant gains still to be made in the dissemination and utilization of U.S. research and technology results. With regard to U.S. research results, we provide for early dissemination of vital NASA results to U.S. industry to assure market advantage, where possible.

Question 7: The National Research Council report, to which I referred in my opening statement, recommends a "reexamination of the research and technology development activity in support of civil aviation in NASA, in light of the changing competitive environment and the technical opportunities noted in this study". Could you share with us your thoughts on this recommendation? To what extent is NASA likely to conduct this "reexamination"?

Answer 7: The NASA Aeronautical Research and Technology program undergoes a reexamination on an annual basis concurrent with the annual budget cycle. In fact the programs are subject to continual review in response to many factors. The needs of the industry, both-near and long-term, are one criteria for review. Other factors are the propriety of the effort in terms of government's role, the overall quality and productivity of the programs, and the significance of the NASA effort in the context of the total national effort. The projected availability of funds is also a major consideration, particularly in programs that must progress through full-scale validation to provide useful results. National policy and goals relating to Aeronautical R&T and Agency goals and directions provide the overall framework in which the programs are examined and structured. With respect to this latter point, the recently announced National Aeronautical R&D Goals have initiated a NASA effort to define a more focused approach to their achievement. The NRC recommendations certainly are being included in these considerations.

Question 8: This report also recommends that NASA consider its activities relative to the validation of new technological advances for certification and public acceptance. Since technology validation is within NASA's charter and because most industrial firms lack the resources to undertake uncertain work of this nature, should NASA reconsider its role relative to technology validation?

Answer 8: The OSTP Aeronautics Policy (1982) reaffirmed NASA's role in the R&T evolution cycle. This role includes research and technology development and demonstration for military-relatd programs. Further, it includes only research and technology development for civil-related activity, except in cases of overriding national need where technology demonstration may be permitted. Research and technology development consists of activities ranging from theoretical analysis to laboratory investigations to flight testing of experimental aircraft. Much of the technology validation occurs during the R&T development phase. Technology validation also occurs as part of the demonstration phase, which is generally the most costly portion of the R&T cycle and provides less in the way of generalizable results. This portion of the cycle is deemed inappropriate as a NASA role for civil-related R&T by Administration policy and furthermore its potential costs far outstrip current levels of resources.

Altitude Wind Tunnel

Question 9: I understand that NASA has $5 million in this budget request for planning related to the development of an Altitude Wind Tunnel at the Lewis Research Center, a development that could cost as much as $160 million. What unique capabilities would this Wind Tunnel provide that do not presently exist in Air Force tunnels or other facilities?

Answer 9: The proposed Altitude Wind Tunnel provides capabilities such as the size of the the test section, the speed, altitude, pressure and temperature simulation that far exceed the capabilities of any other ground test facility in the free world.

These capabilities have been identified as critical to future propulsion system integration R&D by nearly every organization involved in that field.

Prior to adopting the AWT approach, studies were made of other existing facilities to explore alternate approaches to obtaining the required capabilities. The two facilities examined in depth were the 16-foot Transonic Tunnel, (16T) at Arnold Engineering Development Center (AEDC) and the 40-ft.x80-ft.x120-ft. low speed wind tunnel at NASA Ames Research Center. The results were that the magnitude of the modification to the 40x80x120 would result in costs several times higher than those projected for the AWT. While the 16T modification would be in the same range as that now projected for AWT, the 4 to 5 year loss of operation during the modification was considered unacceptable.

Question 10: To what extent will the size of the test section of this tunnel limit the tunnel's ability to test large-size aircraft/propulsion systems, prop-fans or helicopter rotors?

Answer 10: The AWT would eliminate many of the size constraints now encountered in propulsion/airframe integration research. The 20-ft. diameter test section provides for full-scale propulsion systems and significant portions of the airframe necessary to a complete integration test. Translating the projected capabilities into representative current hardware, AWT would be expected to accommodate a full-scale advanced turboprop (14-ft. diameter) with nacelle and the wing section influenced by the propeller; a half-span F-15 aircraft with an operating F-100 engine; a truncated helicopter rotor to examine stresses and ice build up in the critical hub region or a full-scale rotor blade through its full range of angle of attack. At high angles of attack where tunnel blockage becomes the limiting factor, the special test section features of the AWT (finger flaps, plenum evacuation system, tailored slot geometry) will permit the testing of larger scale models than any current medium to high speed wind tunnel. With respect to icing research and testing, the six-fold increase in test section size over the other existing facility provides a major increase in size of models or full-scale components that can be tested. The altitude and temperature simulation provides a substantially improved environment yielding much greater confidence in the results, particularly as they relate to certification questions.

Question 11: What are the projected annual operating costs for the Altitude Wind Tunnel.

Answer 11: The annual operating costs for the AWT are projected to be about $4 million. This amount includes the cost of electricity, fuel, and other consumable items, maintenance, and the salaries of the permanent operating staff, but is exclusive of the research hardware or any special test equipment. The operating basis for these estimates is two shift operation, five days per week with a "wind on" time of 10 hours per week for 50 weeks per year. This operating scenario is based on NASA experience with the other major research facilities. The projected operating cost is consistent with other NASA facilities, but is substantially lower than some large non-NASA facilities such as Aero-propulsion System Test Facility (ASTF).

Question 12: Do you believe that the consensus of industry supports an investment of $160 million and annual operating costs of this magnitude for the Altitude Wind Tunnel at the Lewis Research Center.

Answer 12: During the past two years, the need for the research and test capabilities represented by the AWT has been endorsed by a significant number of organizations including Aeronautics and Space Engineering Board (ASEB), Aeronautics and Astronautics Coordinating Board (AACB), Federal Aviation Administration (FAA), Defense Advanced Research Projects Agency (DARPA), U.S. ARMY, Helicopter Association International (HAI), General Aviation Manufacturers Association (GAMA), and others. During the planning for FY-1986 facility construction funding, similar endorsements were received from senior representatives from both the propulsion and airframe companies. As the FY 1986 budget has become more clearly defined, there has been a growing division within the industry, and within individual companies over the cost of the AWT versus the impact on the research programs. The degree of consensus that existed earlier has declined. A situation not uncommon in attempting to provide a long-term research facility.

Termination of Advanced Composite Structures Technology Program

Question 13: On Monday, the White House Science Advisor, Dr. George Keyworth, released a report that proposed national aeronautical R&D goals in subsonic, supersonic, and transatmospheric transport. Dr. Keyworth said that in the area of subsonic transports, all-composite primary structures would be brought to maturity in the 1990's. Is it possible to develop this composite technology in support of the subsonic transport goal in spite of the Administration's termination of NASA's Advanced Composites Structures Technology program--can industry fulfill this technology objective or should the Administration continue NASA's Composite Structures program?

Answer 13: Each potential manufacturer of advanced aircraft is at a different level of technical readiness for composite primary structural design. This is dependent upon previous experience, ability to transfer technology from other sources, and the level of in-house effort expended. Another important factor is each manufacturer's willingness to expend present and future resources to achieve this capability. NASA has made significant investments ($160M) in composite technology and this resulted in demonstrated composite applications for secondary and empennage aircraft structures. There are many technical challenges to resolve to enable composites to be effectively utilized for primary aircraft structures.

NASA will still continue to support development of this needed fundamental technology for composites in the R&T Base progam. This activity will include: development of new tougher, durable materials; understanding failure mechanisms; and development of advanced structural concepts that efficiently utilize unique design capabilities inherent with composites. The advanced design concepts activity will involve joint NASA/industry programs and will be focused on development of the required technology base to enable composite applications on the next generation transport. NASA believes that previous NASA and other government programs have established a broad data base sufficient to support initial industry development of composites and this future research activity will further the technology base to support industry in the application of composites for primary wing and fuselage structures.

Question 14: Is NASA prepared to request funding for the Advanced Composites Structures Technology (ACST) in fiscal year 1987 in light of the recently-released national goals for aeronautical research and development, or does NASA consider this program terminated?

Answer 14: The ACST program as originally planned has been terminated, with primary impact on the design, fabrication and testing of two composite wing boxes. However, NASA will maintain the current level of funding in the R&T Base for composites technology at approximately $3.5M per year and utilize the $19M of FY 1985 ACST funds over the next two years to support development of advanced composite technology. This future activity will include development of tougher, durable material systems and new composite structural design concepts, including the understanding of structural failure mechanisms. This research will be continually assessed to insure that both technical and funding issues are being properly addressed. We are working with industry to assess technology needs which could be adressed by follow-on programs.

Question 15: How have the assumptions and justifications for the Advanced Composites Structures Technology (ACST) program changed from two years ago when you initiated this program--what is different now than then?

Answer 15: NASA believes the original needs and requirements proposed for the ACST program are still correct; that is, the need to develop a validated engineering technology base for the efficient utilization of composites for heavily-loaded primary aircraft structures. Due to overall budget constraints in FY 1986, a prioritization of the planned aeronautics research efforts was required. These budget constraints required changes to aeronautics program plans and this resulted in the decision to terminate the ACST systems technology program. However, FY 1985 ACST funds and the ongoing composites R&T Base funds will be directed toward maintaining the development of critical composites technology necessary to support industry needs.

Question 16: How do you plan to maximize the utility of your $24 million investment to date in this program?

Answer 16: The total 2-year investment of $24M in the ACST program was used to: (1) establish critical composite fuselage technology design issues and includes fabrication and subsequent testing of scale panel sections to validate fuselage design concepts and (2) establish key technology areas for transport wing structures, however, design, fabrication and testing of two different wing box concepts cannot be accomplished as originally planned. The redirection of the $19M of FY 1985 funds will support joint NASA/industry activities and will address critical design issues such as wing damage tolerance, failure mechanisms, and advanced design concepts that utilize unique structural properties of composites.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS

National Aeronautical R&D Goals Report

Question 1: In a report released this week by the White House Science Advisor, Dr. George Keyworth, the Administration's long term goals for aeronautics were unveiled. This report outlined 3 major goals related to the development of an entirely new generation of fuel-efficient subsonic aircraft, supersonic cruise aircraft and transatmospheric vehicles capable of achieving hypersonic speeds.

Mr. Martin, with these goals in mind, can you tell us how the NASA budget request fulfills these broad goals?

Answer 1: Research which is directly applicable to subsonic transport aircraft is proposed at a level of $70.0 million in the FY 1986 budget request. This includes research for advanced turboprops, viscous drag reduction including laminar flow control, advanced transport operating systems, aircraft safety, advanced cockpit technology, and advanced metallic and composite materials.

Supersonic cruise R&T activity is directed at developing configuration concepts and a technology base for improved future military and civil supersonic cruise aircraft. In the proposed FY 1986 budget, $3.5 million would be devoted to this effort including aerodynamics, advanced aircraft configurations and system studies, high-temperature structures and materials, and integration of supersonic propulsion systems with advanced airframe configurations (including inlets, nozzles, and controls).

A focused hypersonic/transatmospheric R&T program is proposed at a level of $5.6 million in the FY 1986 aeronautics budget request. The program is aimed at fundamental aerodynamics, SCRAMJET and hybrid propulsion systems, and hot structures and materials technology. Directly applicable research totaling $12.3 million is also proposed in the OAST Space R&D budget in the areas of aerothermodynamics, materials and structures, guidance and control, and conceptual design studies.

In addition to the focused programs, generic R&T is planned in the critical technical disciplines which support the development of data and methodology required for future subsonic, supersonic, and hypersonic aircraft design. It should be noted that the national goals were announced in April 1985, three months after submittal of the FY 1986 budget request. NASA will be focusing additional effort in these key areas in the future.

Question 2: In his statement on this report, Dr. Keyworth noted that because government can provide only a part of the technological base and support to achieve future aeronautical goals, the burden will fall on the private sector to supply innovation and leadership. Do you agree with the thrust of these statements? What specifics would you have in mind for industry in this light?

Answer 2: Dr. Keyworth's statements were a reiteration of the respective roles of the private and public sectors established in the OSTP 1982 Aeronautical Policy Report. They also underscore the unparalleled opportunity for advancement that can be achieved if we mobilize all sectors of the aeronautical community, private and public, to focus on common goals. I certainly agree with this approach, as long as the goals are broad-based and are ultimately responsive to national needs. NASA support for a timely and proven technology base for innovation and for development of military and civil systems by the private sector is the fundamental position of the Administration's policy with respect to aeronautics. The traditional partnership between NASA and the aeronautical industry, as reaffirmed by the OSTP Aeronautical Policy Report, provides the framework for continued aeronautics leadership.

Question 3: In your opinion, Dr. Martin, why doesn't the White House request additional funding for NASA aeronautics, especially given increasing calls for a greater focus on these program areas? After all, even the President's Science Advisor has now highlighted the importance of these programs.

Answer 3: The three goals presented in the OSTP report are national goals, the achievement of which will require a commitment on the part of both the private sector and the Federal Government. This kind of partnership in aeronautics has been highly successful throughout the history of aviation, and is one of the reasons for our position of world leadership. The establishment of the national goals is intended to focus U.S. research and technology development efforts in key, high leverage areas.

We recognize, and the White House report acknowledges, the importance of maintaining a broad research and technology base which will enable a broad range of aeronautical advances. The revitalization strategy proposes to reenergize the partnership commitment along the traditional roles of Federal support for technology development and private innovation and system development. Establishment of the national goals is the first step. NASA is currently taking the lead in formulating technology roadmaps as part of an implementation plan for achieving these goals. The results of this effort will define the overall technical approach and funding envelop.

Industry/Government Partnership

Question 4: In his testimony to be given later, Mr. Hopps from the Lockheed Corporation stated that "it was an aggressive NASA/government/industry partnership that provided the U.S. with worldwide dominance in aeronautics." Do you believe that this partnership is any weaker today? Dr. Martin, do you believe NASA should be doing anything different to carry its share of this partnership?

Answer 4: The NASA/industry partnership is as healthy and broad-based today as it has ever been. However, due to the broad range of current opportunities and requirements, it is much more diffuse and possibly less visible than in previous years when we had fewer, but larger, programs.

With regard to NASA's partnership with industry, I believe the OSTP Aeronautical Policy Report (1982) appropriately defines the government and industry roles. As a subsequent step to the policy development, the Office of Science and Technology Policy (OSTP) recently released National Goals which will provide valuable additional focus for U.S. aeronautical research efforts. In addition, the follow-on implementation planning will define the critical technology steps to be conducted within the specified roles. This additional focus and visibility will serve to further, strengthen the already strong partnership within the aeronautical community.

Foreign Competition

Question 5: Administrator Beggs has often spoke of the increased competition from foreign aircraft manufacturers, notably from Europe, and increasingly from Japan. This belief was also put forth in a National Academy of Sciences report released earlier this year on the competitive position of the U.S. civil aircraft manufacturing industry. Given growing concerns of our slipping preeminence, should we be increasing NASA's role in aeronautical research and technology development even more than has been proposed.

Answer 5: In the competition for world market share in civil aviation, the many factors described in the National Academy of Engineers' report are all important and must be considered collectively. Technology superiority alone will not guarantee preeminence, however lack of technical comparability will assure its loss. Rather than changing roles, we should emphasize our traditional national strengths: our ability to aggressively develop and apply new technology to market oriented products. In aeronautics, NASA plays a unique, central role in providing a timely, proven, broad technology base for industry application. Innovation and development by the industry stemming from an enhanced base of new technology can provide technical superiority by a wide margin, potentially offsetting some of the advantages foreign manufacturers enjoy. In order to assure continued preeminence, we must maintain strong support of the technology base which has served the Nation so well in the past and continues to do so.

Congressional Budget Office

Question 6: Earlier this year, the Congressional Budget Office prepared a list of possible program reductions or terminations as possible means for reducing the Federal deficit. One option, and I should stress that these were only options and not recommendations, was to reduce NASA aeronautical funding by about one-third. Dr. Martin, have you or any of your staff had any discussions with CBO on the merits of this option?

Answer 6: No, we have not discussed those options with the Congressional Budget Office. We would, however be seriously concerned if such an option were to be made a recommendation. Reduction by one-third of the NASA aeronautics budget would extend far beyond the technical programs that are underway and planned. It would require substantial reduction in the institution, the facilities and research personnel that represent a major portion of the nation's capability to do aeronautical research. It has taken many years to build this capability which is described in the recent National Academy of Engineering report "The Competitive Status of the U.S. Civil Aviation Manufacturing Industry" as the "linchpin" of the aeronautical complex that will provide our capability for both civil and military aircraft of the future.

Advanced Turboprop Program

Question 7: Mr. Martin, assuming the successful completion of the Advanced Turboprop flight test in 1987, what role would you envision for NASA in furthering this technology? I would appreciate your comments to also reflect the on-going work being conducted by Boeing/General Electric on flight testing a counter-rotational turboprop in 1986.

Answer 7: Successful completion of the Advanced Turboprop (ATP) flight test will provide the scaling verification for structures and acoustics which is necessary to establish advanced turboprop technology readiness. At that point, the data base (including the data obtained by Boeing/General Electric) should be sufficient for industry to decide on the type and configuration of the first commercial advanced turboprop. As our experience with turbofan engines indicates, initial products could be improved substantially through continued research and technology efforts in areas such as materials, acoustics, structures, aerodynamics and system/configuration research, much of which will be based on improvements in analytical capability. NASA plans to continue the important supporting research and technology for turboprops beyond the initial flight test.

The flight test activity is only a portion of the overall NASA broad based, multi-element ATP program that addresses the key issues that are important to all propeller/airframe installations that the industry is considering. The program is also currently addressing cabin acoustics, gearbox technology, installed performance and counter-rotation technology. NASA is pursuing counter-rotation technology through a series of model tests at General Electric and Hamilton Standard, as well as providing approximately 50 percent of the support for the large-scale Unducted Fan (UDF) proof-of-concept test. NASA and General Electric are also negotiating the use of Government owned F404 engines for the referenced industry counter-rotation flight test. In return, NASA would receive access to the data acquired during the tests.

Question 8: One of the industry manufacturers has suggested to the Committee that given the Boeing/GE effort, the importance of NASA's work has been degraded. They have gone further to suggest that the Advanced Turboprop program could probably be limited to just testing the quick engine change (QEC) concept on the ground and in a high-speed wind tunnel. They argue that these activities would probably fulfill the objectives of the flight test with significant savings. What are your thoughts on this proposal?

Answer 8: The Boeing/General Electric effort does not diminish NASA's lead role in developing a generic technology base in Advanced Turboprop (ATP) performance, structures and acoustics. The planned

FY 1987 flight test is a necessary part of a broad-based, multi-element technology program that addresses the key issues important to all propeller/airframe installations being considered by the industry. The flight test of a large-scale, single-rotation propeller is addressing aeroelastic performance and acoustics which cannot be adequately verified in small-scale model testing. Static ground tests do not provide the proper conditions for aeroelastic and acoustic evaluations and there are no high-speed wind tunnels large enough to test a large-scale ATP propulsion system. The flight test data will be used to provide the scaling verification for structural and acoustic analytical predictive techniques which are applicable to all ATP configurations including counter-rotation. The scaling verification will be the final input to an extensive data base being developed on single-rotation through subscale isolated and installed propeller experimental evaluations as well as largescale blade structural technology development that includes static and wind tunnel testing. This data base of a relatively simple configuration forms the baseline for future design and configuration iterations.

On the other hand, industry is concentrating on specific concepts and configurations that it feels will be viable for products in the early 1990's, and is pursuing near-term flight demonstrations to confirm their performance potential. However, until the technology base is completed and verified for various propeller and drive system configurations along with the related aircraft technologies, it is not clear which configuration(s) will yield the most potential for any future product development.

Composites

Question 9: Mr. Martin, in your statement you say that the decision to terminate the Advanced Composite Structures Technology program was made based on the recognition of earlier significant investments by NASA, as well as the belief that industry was better positioned to continue work in large section composite R&D. If this is true, why did NASA submit a request of $25.9 million for this program to OMB?

Answer 9: Due to budget constraints in FY 1986, a prioritization of the planned research efforts was required. These budget constraints required major changes to program plans. It was in this environment that the decision to terminate the ACST program evolved. The technical rationale for this decision is cited in the previous testimony.

Question 10: One key concern with respect to the Advanced composite program is that industry may not be ready to take over the entire effort without govenment assistance. Some industry experts predict that the effect of eliminating this NASA program would be a 3-5 year delay in the technical readiness of U.S. manufacturers in producing fuselage and wing composite structures. Do you agree with this assessment? Do you believe it is important that this technology be available for application to the next generation of transport aircraft?

Answer 10: Two factors must be considered in the assessment of the prediction that the elimination of Advanced Composite Structures Technology program will cause a 3-5 year delay in technical readiness of composite primary structure. The first factor is the current technical capability and composites state-of-the-art resident with each potential manufacturer of advanced aircraft. Each one is at a different level, dependent upon previous experience, ability to transfer technology from other sources, and the level of in-house effort chosen to be expended. The second factor to consider is each manufacturer's willingness to expend present and future resources to achieve this capability.

NASA believes that the benefits to be derived from composite primary structure are substantial and that it is very important that this technology be available for application to the next generation of transport aircraft. It is NASA's position that previous NASA and other government programs have established a broad data base sufficient to support the manufacturers' development of composite primary structure if they are willing to invest the required resources. NASA will continue to support fundamental composite technology development through the in-house R&T Base programs which are concentrating on advanced materials development, structural mechanics including predicition of failure mechanisms, and the development of advanced design concepts in joint efforts with the industry.

Hypersonic Research

Question 11: Last year Congress increased funding for R&D on hypersonic vehicles. What achievements has NASA made to date in this area of work? What is NASA's long-term strategy with respect to hypersonic cruise aircraft?

Answer 11: The Committee on Science and Technology attempted to provide a $5.0M augmentation to the NASA FY 1985 Authorization bill. The increased funding did not survive the full House of Representatives vote on the bill. The report did, however, request that NASA prepare and submit a plan for research in High Speed Aeronautics. The plan, entitled "A Focused Hypersonic Research Program" was submitted as requested on November 30, 1984. As described in the plan, the on-going NASA program is a level of effort research and technology program; $5.6M is directed to hypersonics in the NASA FY 1986 request.

The NASA Hypersonics program is divided into four major discipline elements: Supersonic Combustion RAMJET (SCRAMJET) propulsion, high temperature materials and structures, propulsion systems/airframe integration and aerodynamics/configurations. For the last six or seven years more than one half of the annual funding has been concentrated on the most critical technology - SCRAMJET propulsion. Achievements in this area are extremely significant and unique - possibly a breakthrough in propulsion technology. The SCRAMJET concept developed by NASA-Langley Research Center (LARC) is a propulsion module with a fixed geometry nozzle and inlet that uses hydrogen as the fuel. Stable operation has been demonstrated at Mach 3 flow conditions with subsonic combustion and Mach 7 flow conditions with supersonic combustion. Positive net thrust has been measured at both conditions. A design for a test module is being developed and long lead time component fabrication is underway to provide an integrated large scale propulsion module that will be tested in the modified 8 foot High Temperature Tunnel facility at NASA LaRC in the 1988-89 time period.

Another significant research achievement has been accomplished in high temperature structures where technologists have been able to design high temperature insulated structural concepts that are reusable; flexible, when loaded at high Mach number flight conditions; and able to accommodate wide range thermal expansion from cyrogenic hydrogen fuel tank temperatures (-420°F) to steady state cruise operations at (1600°F). These advanced structural concepts will be designed, built and extensively tested over the next several years.

NASA long-term strategy in hypersonics is still evolving due to a variety of related studies and coordination activities currently underway. In addition to the NASA report to Congress, the Office of Science and Technology Policy has recently announced national goals for aeronautics which included a specific goal for transatmospheric/hypersonic capability. Another ongoing study is associated with the Aeronautics and Astronautics Coordinating Board (AACB) which is conducting an activity to coordinate the NASA plan with the several DOD programs. Further coordination efforts with industry and DOD are underway to define the important technology developments required for this vehicle class.

NASA believes that hypersonics research is a very important area for increased national emphasis and we expect to place increased emphasis on our research efforts in this area.

Oblique Wing

Question 12: Mr. Martin, early in your statement you note that "it is important that most of NASA's aeronautical research has common applicability to both military and civil aircraft." At first glance, it is difficult to envision how the oblique wing, which is being jointly funded by the Navy, could fit into the needs of the civil aircraft fleet in the near future. What, if any, civil applications would you envision for the oblique wing?

Answer 12: NASA has for many years investigated the oblique wing configuration which included wind tunnel tests, simulations, low speed flight tests and aircraft design studies. These investigations have shown that for missions that require a long endurance or long range flight, as well as a supersonic flight segment, the oblique wing offers lower drag and lower structural weights than either a fixed or conventional variable-sweep wing.

The potential civil applications of the oblique wing concept are envisioned to include a transcontinental supersonic transport and a high-speed business jet capable of operating from normal runway lengths (high aspect ratio wing during takeoff and landing). During the 1970's there were several studies of oblique wing transport configurations that could fly at low supersonic speeds (Mach = 1.2) and not cause a sonic boom over populated areas. A study conducted by the Boeing Company compared oblique-winged aircraft with fixed-wing and symmetric sweep aircraft for the transcontinental supersonic mission. The findings of this study indicate that:

1. The oblique wing concept provided the potential for a lighter and quieter aircraft for the transport mission, considering aircraft noise and sonic boom constraints.

2. For missions where variable wing sweep is warranted, then the advantages of the oblique wing concept should be seriously considered.

However, these findings were overshadowed at that time by a far more important turn of events, namely that the oil crisis of the 1970's caused fuel prices to rise from roughly 13 cents a gallon to over one dollar a gallon. With these prices, the economics of supersonic civilian transportation were severely affected. While further studies investigated lower speed applications, the advantages of the oblique wing were not sufficient to make high subsonic aircraft clearly attractive. The performance advantages identified in these studies did not include all the lower structural weight advantages which more recent investigations have identified.

X-29 Aircraft

Question 13: With the X-29A Forward-Swept Wing aircraft having begun its flight testing program, what will be NASA's future role with respect to this aircraft?

Answer 13: After the conclusion of the functional flight testing of the aircraft by the contractor (Grumman), NASA has the overall responsibility for conduct of the government flight test program to evaluate the X-29 aircraft concept which includes responsibilities for flight safety, test planning, configuration control, data processing and reporting. The objectives of the NASA flight testing are to expand the operating envelope to the limits of the aircraft capability and to demonstrate and evaluate the advances in flight vehicle capabilities provided by the X-29's set of advanced technologies, and to provide the data and confidence necessary to transition X-29 technologies to future military systems. During this flight test phase NASA will employ a combination of design, analysis, ground testing and flight test techniques to accomplish these objectives.

Controlled Impact Demonstration

Question 14: Was NASA able to obtain adequate data to fulfill its objectives in the Controlled Impact Demonstration project last year? What were the highlights of these findings and how will this information be put to use?

Answer 14: NASA's major objective was to obtain structural response measurements of the 720 aircraft at impact. NASA developed the on-board data acquisition system and ten on-board cameras for obtaining this information. All ten cameras worked and recorded the cabin behavior at impact. Ninety-seven percent of accelerometers were active at impact. We measured structural response and load path definition at impact. The total fuselage impact loads were survivable using accepted criteria for human tolerance. The peak vertical acceleration loads along the floor were highest in the cockpit and forward cabin, approximately 15 g's. The remaining cabin floor received vertical acceleration peaks generally about 7 g's or less. The peak longitudinal acceleration levels showed similar distribution with the highest level being 14 g's in the forward cabin and levels generally less than 4 g's over the rest of the floor. Lateral impact load peaks on the floor were also generally low. The results are being reduced and summarized for a data base for understanding transport dynamics under impact loads and will be published in a formal NASA report by the end of 1985.

Numerical Aerodynamic Simulator

Question 15: Some industry officials have expressed a concern that NASA is moving too fast into the Numerical Aerodynamic Simulation (NAS) program. Specifically, they argue that by slowing down the NAS program, new and better technologies may be available in the coming years. What is your response to this idea?

Answer 15: The Numerical Aerodynamic Simulation (NAS) program is a long term research endeavor which depends initially on a five-year facility development to provide an advanced computational capability which is essential to the national aeronautical research program. The objective is to develop and maintain a premier national scientific computational capability for the aerospace community which would be available to NASA, industry, DOD, other federal agencies, and the university community. Planning for the NAS began in the mid-1970's and the initial five-year development, which was approved as an FY 1984 new start, is timed to capitalize on the introduction of the next generation supercomputers. This timing was planned to ensure continued U.S. preeminence in aeronautics through early application of new, highly advanced supercomputer technologies. These technologies offer new capabilities important to vital aeronautical research which is needed today; it cannot be abandoned simply because further advances are anticipated in the future.

The current NAS development schedule relies on several major contracts and procurements already in place. Slowing the NAS development would cause not only schedule slippages and missed technology opportunities, but would entail costly renegotiation of these existing contracts. All of the Initial Operating Configuration (IOC) system components have been procured and some have already been delivered. The IOC implementation will occur in mid-1986. Any delays in the NAS implementation will also have a major impact on the Extended Operating Configuration (EOC), which is planned to permit the initiation of classified processing to support critical national defense programs, and broadband networking which will provide access to NAS by the national user community. NAS represents the first major new national facility in a process of transition to a revolutionary approach to aeronautical research: parametric simulation as a pathfinder and driver of experimental analysis. It is a complementary capability which will greatly enhance the national aeronautical research capability. The nation's

21st century aerospace vehicles will be designed and developed using new and better computer science technologies which, as you suggested, will be available in the future. However, the methods and techniques employed will be based on results of the NAS program research, which requires the most advanced supercomputer technologies available now.

We note that since the central processing units (supercomputer) are leased, we certainly plan to continuously evaluate them against any future state-of-the-art systems and, if necessary, upgrade them so as to maintain the most advanced capability possible.

X-Wing Aircraft

Question 16: What is the Defense Department's share of funding in the RSRA/X-Wing flight program?

Answer 16: The funding share by the Department of Defense (DARPA) for the RSRA/X-Wing flight program is $49 million of the $91.5 million total. To date DARPA has contributed $46.4 million and in FY 1986 they will provide the balance of $2.6 million.

Rotorcraft Systems Technology

Question 17: In the bill reported last week by the House Committee on Science and Technology, $4.0 million was added to the NASA authorization level for Rotorcraft Systems Technology. If this additional money were included in the final conference report for NASA's FY 1986 authorization, what specific activities would NASA fund?

Answer 17: The $4.0 million additional funding in Rotorcraft Systems Technology that you have referred to would support a joint NASA/industry program for the prediction and control of rotorcraft vibration. This cooperative would involve the shared resources of four helicopter companies in jointly attacking the problem of vibration prediction in the design stage. In addition, the funding would enable NASA to address the need for airload data on a modern, 4-bladed rotor at high speeds.

Altitude Wind Tunnel

Question 18: What effect would the elimination of funds for the Altitude Wind Tunnel have on NASA's aeronautical research work?

Answer 18: The criticality of propulsion/airframe integration grows in proportion to the level of performance required of the vehicle. In the next generation of aircraft, the effect of the aerodynamics of the vehicle on the operation of the propulsion system may well become the governing factor in establishing new configurations. The FY 1986 Altitude Wind Tunnel (AWT) funds in question are for analysis, simulation and scale model tests, not for construction of the facility. These activities will ensure that the AWT flow characteristics and the test section features which will enable testing of high blockage models are correctly reflected in the final design of the facility. Lessons learned from other major facility projects make it clear that this up-front R&D effort is essential.

The AWT program has been endorsed by a substantial number of knowledgeable organizations as fulfilling the future critical needs for large scale propulsion system integration research and test capability with true altitude temperature and pressure simulation. The environment provided by the AWT far exceeds the capability available through any other ground facility and could alternatively only be achieved in flight. The 20-foot diameter test section with its special capabilities will provide for testing of full scale turboprops, (14-foot diameter) and models as large as a full scale, half-span F-15 with an F-100 engine. In addition, the AWT would provide a sixfold increase in test section area over any other facility capable of icing research.

Hot Section Technology Program

Question 19: NASA's FY 1986 budget request proposes the stretching out of the hot section technology program. What are the primary objectives of this program, and what effect will this delay have on meeting those goals? Does NASA support the $2.0 million restoration of funds included in the House bill?

Answer 19: The Hot Section Technology program managed by Lewis Research Center has the objective to develop the analytical tools and experimental data necessary to accurately predict life and assess the durability of advanced turbine engine hot section components such as combustor liners and turbine vanes and blades. The program was planned and initiated as a five year program in FY 1981 at a total cost of $34.5 million. Recognition of the program's high payoff later resulted in an expansion of the activity through FY 1989 for a total of $52.0 million.

Budgetary constraints in FY 1986 resulted in the need to descope the effort through the limitation of some model/system validation testing using component rig and/or full-scale engine tests. However, all major milestones in the development of generic analytical models and generation of benchmark quality data for selected model validation will be met. Accordingly, NASA does not believe that a restoration of $2.0 million is required to achieve the technical objectives originally planned for the program.

Senator GORTON. We will now hear from our second panel: Dr. Krone, Dr. Shank, Mr. Kirchner, Mr. Schaufele, and Mr. Hopps.

Because of the time and the size of this panel, we are going to have to impose a strict 5-minute limitation on your opening statements, indicated by the set of lights in front of me here. In each case, I want to emphasize that we have your statements and each written statement will be included in the record as if read. So summaries from you will be greatly appreciated.

We will start with Dr. Krone.

STATEMENTS OF NORRIS KRONE, REPESENTING THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS; M.E. SHANK, DIRECTOR, ENGINEERING TECHNICAL ASSESSMENT, PRATT & WHITNEY ENGINEERING DIVISION, UNITED TECHNOLOGIES, EAST HARTFORD, CT; MARK KIRCHNER, DIRECTOR, ENGINEERING TECHNOLOGY, BOEING COMMERCIAL AIRPLANE CO., SEATTLE, WA; ROGER D. SCHAUFELE, VICE PRESIDENT OF ENGINEERING, DOUGLAS AIRCRAFT CO., LONG BEACH, CA; AND RUSSELL HOPPS, LOCKHEED-CALIFORNIA, BURBANK, CA

Mr. KRONE. Yes, Senator, I appreciate very much your invitation and the opportunity to express the views of the American Institute of Aeronautics and Astronautics, the AIAA. I represent and I am the chairman of an advisory committee of that organization for national aeronatics, and in that regard this committee was taken from the 35,000 membership of the nonprofit society, the AIAA, and represent a broad cross section of aeronautical experience and expertise.

As a matter of fact, those members are currently in key technological areas within their organizations. In other words, they are involved in making decisions relative to the aeronautical technology on a daily basis.

We believe that the aerospace industry itself is a very large and economically important industry to the country—1.2 million workers, $83 billion in sales last year, $50 billion payroll, and, most importantly, $10.2 million in positive balance of trade—in the aerospace business; and there is a very definite reason for this, that reason being that our products are superior to our competitors. They are superior because of the investment of the past in the aeronautical technology areas.

We are concerned about a trend that is downward—the one you mentioned at the beginning of this meeting. I will not go through that, but the auto industry, the shipbuilding and the steel industries experienced similar trends over the last 30 years, going back to World War II, and our concern is that we are on a road that is similar to that experience.

With a projected $525 billion aeronautical business prospect or estimate for the next 10 years, we feel that the technology development that we do today is going to be very key to the ability to capture portions of that business in the future.

Now, we do not think the NASA aeronautics budget represents an aggressive commitment to capturing a large portion and maintaining the dominance in aeronautics that we have had in the past.

We say that because of the fact that of the total NASA budget only about 7.9 percent of it goes toward aeronautics. That point is even further emphasized by the fact that in 1986, actually starting with this year and continuing in 1986, there were a number of what are called technology demonstration, technology development demonstration programs, like the X-wing, the X-29, and the oblique wing—also, the turboprop and the large composite programs.

The point we would like to make here is that these are in the same funding lines with the R&T base programs, essentially considered against them when decisions relative to the funding allocations are made, and those demonstration programs are rather large in nature.

We do not feel that they should be in the same category of budget consideration because they perturbate rather significantly from year to year. Just because there is a need for a demonstration this year or next year does not mean that the R&T base in that particular area should be reduced.

We very definitely support the demonstration programs because we feel that they are the key for transitioning technology from the laboratory into the production or the product world. Essentially they form the link and the confidence-building element, as well as, giving direction to future technology efforts. So we feel that there ought to be something done about the mechanism by which those programs are funded. In other words, there ought to be funding wedges put into the budget for those kinds of programs separate from the R&T budget.

In support of the statement that we do not believe that the 1986 aeronautical R&T effort is commensurate with the potential return on the investment over the next 10 years, we have selected five technology areas where there has been a reduction and areas that should be strengthened.

The NAS, the numerical aerodynamics simulation, that was talked about just a few minutes ago, along with the computational fluid dynamics, is an area we strongly support, however. We do not see that there is an ancillary experimental verification and correlation effort that should go along with that work. In other words, with that greatly increased capability we should have wind tunnel and experimental work to support it. The rotocraft area, the advanced structural programs, and the composite programs, and the material metal matrix are other areas. We support the HOST program. We do not believe it is supported at a high enough level, as well as the hypersonics technologies, where the thermal chemistry differences between normal supersonics and hypersonics is not well understood at this time.

Thank you very much. I see my time is up.

[The statement follows:]

STATEMENT OF DR. NORRIS J. KRONE, CHAIRMAN, AD HOC ADVISORY COMMITTEE ON NATIONAL AERONAUTICS, AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

THE STATUS OF NATIONAL AERONAUTICS

The U.S. aerospace industry plays a very significant role in the nation's economy, with a work force in excess of 1.242 million, total sales of $83.1 billion, and a payroll of greater than $50 billion. In addition aerospace sales have a remarkable "multiplier" effect; for example, the sale of a large commercial jet creates thousands of jobs, in the construction, food and beverage, agriculture and furniture industries to name just a few. In 1984, the aerospace balance of trade was a positive $10.2 billion, in contrast to the remainder of the U.S. economy, which had a large negative balance--a situation that is even more critical this year.

During the 1970s, the inflation rate for U.S. business as a whole was 7 per cent; for high-technology enterprises it was 2.5 percent. While overall productivity grew at 0.9 percent during this period, in high technology industry the growth rate was 5.6 percent. Aeronautical products are by their nature high technology products and are to a large degree judged on a relative scale with similar prodcuts developed by competing countries. The sales of commercial and military aircraft and the enormous parts and supply business that is associated with these aircraft make up the lion's share of the over-all business of the aerospace industry, and this activity is highly dependent for its future upon a superior level of technology.

In addition to the economic payoffs the aeronautical industry makes absolutely essential contributions to national security. Our current security posture is to counteract the numerical superiority of our Warsaw Pact adversaries with superior technology (and therefore superior performance) in our tactical and strategic systems and their supporting infra-structures. Leadership in aeronautics has become an integral and unavoidable component of our national security capability. The very real and frightening point is that continued U.S. eminence in aeronautics will not continue automatically, and the facts show a decline. Other industries have had similar historical trends. Having dominated the international automobile market for over half a century, the United States saw its share of world auto trade collapse from 75 percent to 20 percent in just 30 years. Our share of the world steel market went from 60 percent to 15 percent in 35 years. A similar historical situation exists in the ship building industry. It is not inconceivable that our current lead in aeronautics could be similiarly threatened unless we take the positive steps necessary to maintain it. Without question it is crystal clear that our economic and military competitors recognize the importance of aeronautical technology and are intent upon closing the lead we have enjoyed. As a matter of fact, foreign competitors in aeronautics have been making advances relative to the pace of progress in our country. The Soviet Union has developed two strategic manned bomber weapon systems that afford them an extremely flexible military capability. The Backfire and the more recent Blackjack threaten not only our country and the homelands of our allies but also the naval lifelines that are necessary for effective cooperation between the allies. These manned bombers, when equipped with long range, high technology cruies missiles, equate to a major threat to the sea lanes and naval operations. Turning now to the fighter aircraft and tactical systems, the Soviets continue to develop, test, and deploy (in great numbers) fighter aircraft. Our viability depends upon countering their numerical advantage with much greater technical performance. The Soviet Union has deployed the Foxhound (MIG-31), a more advanced follow-on to the Foxbat. In addition, they have deployed in large numbers two other new fighters, the Fulcrum (MIG-29) and the Flanker (SU-27) The F-18 is the only new U.S. aircraft to have entered service in the 1980s. We have been studying an advanced tactical fighter since the mid 1970s but have not yet made a decision to develop a prototype of an F-15 follow-on aircraft. Also we need to find a way to eliminate the excessive time that is now required to develop new weapon systems.

On the commercial scene, foreign aeronautical firms continue to progress with gains in many areas. In 1983 unit sales of U.S. business, private and light transport aircraft was 2,691 units--a dramatic drop from the 17,811 unit sales in 1978. During 1984 civil aircraft sales declined from the 1983 level of $12.2 billion to $9.8 billion, a 22 percent drop. Unit shipments of both commercial and general aviation aircraft dropped 29 percent and 12 percent respectively. These figures reflect the growing quality and attractiveness of foreign civil aircraft designs, as well as other sales inducements being offered by the competition.

A significant reason for this trend is the increasing support given to the foreign aircraft industries by their governments. In almost all of the competing countries the government either owns, provides direct support to or encourages industrial consolidation, practices that would violate anti-trust statutes in the U.S. The Canadian government has provided $750 million of direct financial support to Canadair over the past three years. Other reasons for concern are the price disadvantages on the world market caused by the strong dollar, and the barriers in a number of countries to market access by U.S. products.

One response to this adverse situation was the formulation of the "Aeronautical Research and Technology Policy" by the Office of Science and Technology Policy. It was firmly established that superior capability in aeronautics is a unique and vital national asset essential to the national security. There were a number of key technologies identified and determined to be extremely important by the policy document. These included:

(1) Aerodynamics where 20-40 percent reduction in drag is believed possible

(2) Composite material development where 20-30 percent reduction in structural weight is possible

(3) Propulsion systems where reductions in specific fuel consumption of 15 to 20 percent are expected.

The integration of these and other technologies were predicted to provide the potential to increase speed and range by 100 percent and reduce life-cycle costs by 25-50 percent. The prognosis for the next ten years is for a free world aeronautics product market of approximately 535 billion dollars including both military and civil aircraft. The proportion of this market that is captured by the U.S. is directly related to the investment we make in today's aeronautical technology programs. Dollars spent in the aeronautics technology areas today should be considered a wise investment that will yield large financial and security dividends in the future.

NASA FY 86 AERONAUTICS PROGRAM

GENERAL LEVEL

The FY 86 NASA aeronautics program does not reflect a strong commitment to maintaining the U.S. as the dominant aeronautical country in the world. Of the total $7.886 billion NASA budget, only $622 million, or 7.9 percent, is dedicated to aeronautics. For the last three years the aeronautical research and technology programs have been funded at approximately the same level (in 1982 dollars) - the lowest since the early 70s.

In real terms the Research & Technology base programs have been significantly reduced to accommodate a number of relatively large technology demonstration efforts.

TECHNOLOGY DEVELOPMENT DEMONSTRATION PROGRAMS

Although we strongly support the large technology demonstration efforts such as the X-Wing, the X-29, the Oblique Wing and the Advanced Turboprop (ATP), they introduce large step functions in technology funding requirements. By their nature, the technology development demonstration programs are aimed at relatively near term benefits and are in many cases the final step of a long period of research in one or more technology areas. Usually a development demonstration program serves as an important step to provide the confidence that a given level of technology (or set of technologies) is ready for practical application and that it integrates well with other technical advances in the real world environment. Because a given technology sub-set of the larger technology field reaches a level where a demonstration is needed does not mean that the rest of the technology base programs should be reduced! This is precisely what has happened--it happened in the case of the ATP development demonstration program. As the direct result of greater funding requirements for the ATP demonstration, other very important propulsion and aerodynamic technology base programs were cut or greatly reduced.

The current structure of the NASA organization and budget are a contributing cause of this problem. We believe the large aeronautical technology development demonstration programs should constitute a funding line item apart from the technology base programs--just as the space flight programs are separate line items. The need for additional funding for a large demonstration would then be played against other major items in the entire NASA budget and not just those in its own relatively narrow technology area. Also, budgetary flexibility should be provided to allow for these large demonstration programs to be judged on their financial needs from year to year with the potential for large yearly changes (up or down). For long-term planning, funding wedges should be included for the out years in anticipation of these programs with a requirement for yearly justification.

TECHNOLOGY BASE PROGRAMS

Now, turning to the technology base program, we strongly recommend a significant increase in the following areas:

1. Aerodynamic verification and correlation

2. Rotorcraft technologies

3. Advanced composites and aluminum alloy technology

4. Engine Hot Section technology

5. Hypersonic Basic Research

AERODYNAMIC VERIFICATION AND CORRELATION - The 1986 NASA Research and Technology Base program includes substantial investment in computational aerodynamic codes and computer facilities. Computational aerodynamics provides government and industry researchers with a powerful new tool which provides insight into complicated external and internal aerodynamic phenomena.

The computational capability is needed to support the design and development of highly capable new military and civilian aircraft and propulsion systems. Without this capability, designers and analysts are forced to rely only on experimental and/or approximate analytical procedures. These traditional tools have been the basis for aeronautical development for the past 50 years, they have served us well, and they will continue to be the backbone of our development activities. The challenges of the future require the more sophisticated and accurate procedures that computational aerodynamic codes and facilities can provide, but these new tools are far from perfect.

The development of the advanced computational capability must be accompanied by a vigorous and systematic program to provide comprehensive experimental verification and correlation of the analytical predictions. This is particularly important in the near term (1986-1990), when many in industry and government will be significantly increasing their reliance on computational methods. Unless comprehensive and unambiguous experimental data is available to substantiate and correlate analytical predictions, the designers and analysts will not have the confidence to apply them to their full potential and important new aeronautical capabilities will go unrealized.

The experimental verificaton program must be carefully structured and expanded to cover the full range of configurations and aerodynamic phenomena to which the computational procedures are applied. The causes and effects which influence the results must be carefully isolated and correlated. Many of the tests required may be generic and could appear routine at first glance, and because of this routine appearance, it may be difficult for the experimental verification program to achieve the agency and political advocacy needed to ensure vigorous growth and program viability. It is important to realize that experimental verification is a vital element of the overall computational aerodynamics program, and it must receive at least equal emphasis to the development of the codes and computer facilities themselves. To do otherwise will result in less than desirable return on investment and could, if experimental verification is slighted, waste a portion of a vital national resource.

ROTORCRAFT TECHNOLOGIES - The rotorcraft portion of this country's aerospace activity has probably been its most rapidly growing element in recent years. Capabilities of helicopters have improved very measurably and the numbers of aircraft used by both civil and military operators - approximately 40 percent of the military vehicles are rotorcraft - has grown substantially. The trend is continuing as more missions are identified and as lower operating costs bring rotorcraft within reach of more potential users. For example, a whole new market has developed in the use of helicopters by emergency medical services (EMS). Additionally, more and more countries around the world are now able to afford helicopters for their own self-defense or for economic development.

In spite of this upward trend in rotorcraft use, the present NASA budget shows declining rotorcraft technology support - especially if the recent X-Wing demonstration funding requirement is considered separately. The rotorcraft systems budget is programmed to reach zero by FY 88 and needed increases in the R & T base elements are not scheduled. This is true despite the fact that substantial progress in developing greater performance at lower costs is possible if the effort is made. The NASA Advisory Committee's Subcommittee on Rotorcraft Technology defined a priority list of areas deserving attention during 1984, and this list is still valid. At the top of the list is the reduction of external noise where a very productive effort promoted by the American Helicopter Society and the FAA was established and funded by a corporate NASA/Industry program. This program has been cited as exemplary; however, the problem is far from solved, and it is too soon for the scheduled phase-down by NASA.

Another NASA/Army/industry program aimed at the reduction of rotorcraft vibrations does not appear in the 86 budget. This effort is aimed at extending the applicaton of NASTRAN, the NASA developed finite element structural modeling tool, to the complex problem of predicting dynamic response of the higher modes of rotorcraft structures. The prediction of dynamic response of complex higher modes at important frequencies (about 20 Hz) is beyond current capabilities. A comprehensive documentation and correlation of a NASTRAN methodology, for both metal and composite airframes, should be continued.

A third rotorcraft area that requires additional support is that of handling qualities and active control. Modern digital electronics offer substantial benefits to the rotorcraft community by making these inherently less stable aircraft easier and safer to fly. A fundamental program to define the practical limits of "Super Augmented Rotorcraft" has been identified and is highly recommended for support.

Beyond these top three rotorcraft projects, continuing beneficial efforts have been identified in performance, cockpit criteria, propulsion systems, internal noise, new materials application, and icing prevention. Large improvements in future helicopter performance are certainly possible and the needed technology investments to make them a reality are disproportionately modest.

ADVANCED STRUCTURAL MATERIALS - The potential of advanced composites as primary structure is among the highest of those technologies projected to be available for the next generation subsonic transport. The total structural weight of an aircraft in this class can be reduced by 15-20 percent with large increases in operating efficiency.

During 1984-85 NASA initiated contracts with industry aimed at developing the technology needed to reduce the risk of application of advanced composite materials to the early primary structure of a next generation subsonic transport aircraft. The specific objectives of this activity were associated with large transport wing and fuselage structures. The wing structures program included: (1) The development of manufacturing technology for fabrication of large, thick skins economically, (2) Development of efficient joints for transferring large loads and included pylon/flop attachments, and (3) The development of techniques to allow integrated storage of fuel inside these structures. The fuselage program includes an effort aimed at a better understanding of durability and damage tolerance containment, critical joints and cut-outs and eoustic transmission.

Application ~~of~~ advanced composites to primary structure of future subsonic transport aircraft is clearly necessary to maintain the U.S. competitive position in the international market. This position can be seriously jeopardized if the advanced composite work on large structures is abandoned.

Aluminum alloy improvements are also of particular importance because of the extensive manufacturing capability and experience extant in the aircraft industry. As a matter of fact, a difficulty associated with the adoption of advanced composite materials is the heavy capital investment already sunk in the aluminum manufacturing equipment and the additional capital that is required to build composite structures. Therefore, it is prudent to develop more capable aluminum alloys while phasing-in the utilization of advanced composite materials with an ultimate goal of a balanced capability for the efficient use of both classes of materials.

Potential aluminum alloy improvements have been identified to be the lithium alloys (ingot and powdered metallurgy), high temperature alloys, and aluminum matrix advanced composites. The aluminum/lithium alloy activity is directed at developing an alloy of better strength and toughness than present alloys and with an 8-12 percent lower density--thus producing a direct weight reduction without the need for new fabrication techniques or new facilities. The aluminum and aerospace companies are spending substantial amounts aimed at exploiting this area; however,there are significant problems that remain. There is modest government support of this activity and, as a consequence, its use is being pushed farther into the future. Estimates of the usability dates of these materials by the aluminum companies have now slipped into the nineties.

The thrust of the high temperature aluminum alloys work is to replace titanium with aluminum for 400-600 degrees Fahrenheit temperature applications and thereby reduce costs and weight of future vehicles. There is a limited amount of Air Force support for this work and only a minimal research support effort by NASA.

Metal matrix materials consist of high strength fibers such as silicon carbide or boron, imbedded in aluminum. The payoff of the matrix material is a substantial reduction in structural weight which has been verified by studies of large transport type aircraft that indicate a 35 percent reduction in structural weight when 33 percent of the structural material is metal matrix. This saving results from a complete resizing of the aircraft with lower associated engine power and reduced fuel requirements. Metal matrix materials development is being supported at a level well below one commensurate with its potential payoffs.

TURBINE ENGINE HOT SECTION (HOST) PROGRAM - The NASA sponsored Turbine Engine Hot Section Technology (HOST) program was initiated in FY 1981 for the purpose of developing the technology needed to double the life of engine hot section components and reduce the hot section maintenance cost of gas turbine engines by 30 percent. The program as originally conceived was scheduled for eight to ten years with 40 percent of the effort programmed to support in-house government activities and the remainder for industry, research firms, and universities. The original projections for the program cost were in the $100 million range.

NASA did a commendable job in implementing the program and as a result efforts to improve the understanding of the gas turbine hot section aerothermal environment and material structural responses is presently underway through a combination of contracts, grants and NASA in-house research activities. Advanced instrumentation such as optical viewing devices and thin film sensors are being used to better determine actual hot section conditions. Also, some advanced thermal and structural computer codes, calibrated by laboratory experiments and exisiting gas turbine data, have been developed for government and industry use. However, considerable additional work of this nature remains to be done in order to reap the potential benefits in this important key area for improving engine performance.

The relative distribution of HOST funds between government and industry is consistent with the original plan. However, the program funding has averaged only $5 million since its inception and indications are that, although this program has been held in high esteem by the gas turbine community, it will be phased out before its full potential is reached. The $9.2 million HOST budget for FY 85 is adequate to continue existing work including the purchase of some contract options, but no funds exist to initiate new and needed contracts or unversity grants. In a real sense, the HOST Program has been de-emphasized and is presently scheduled to end in FY 89--well before its real potential is reached.

HYPERSONIC TECHNOLOGIES - During the 1950s and 60s aerodynamic research was dominated to a large degree by the high mach number regime generally described as hypersonic. This work was highly motivated by the Apollo program, the ICBM re-entry work, and the general thrust towards higher and faster flying vehicles. After completion of the Apollo program and with the basic solution of the ballistic missile re-entry problem, there was a definite mothballing of hypersonics research--many hypersonics wind tunnels and shock tubes were decommissioned and actually cut up for scrap. Fortunately, the NASA facilities remain intact. With only a few exceptions the hypersonic research programs have gone extinct in American universities--a situation that has created a real manpower shortage in addition to the facility problems. In essence, we have lost over a decade of opportunity for developing truly advanced hypersonic technology.

With the resurgence of interest in hypersonic vehicles and mission areas such as a second-generation space shuttle, aero-assisted orbital transfer vehicles, the transatmospheric vehicle and hypersonic missiles for application of high-kinetic-energy penetrators, there is a critical need to rebuild our hypersonic research and technology capabilities. One aspect of this technology is very encouraging. The analysis techniques have been revolutionized by the Computational Fluid Dynamic (CFD) methods which will use the Numerical Aerodynamic Simulation (NAS) facilities with their advanced high speed computers. NASA is providing heavy support for the NAS activities, but there is a strong need for additional research into the physical chemistry that separates the hypersonic regime from the lower speed aerodynamics. Experimental correlation of the analytic methods is absolutely essential if viable and efficient hypersonic vehicles are to become a reality.

CONCLUSIONS:

The bottom line of our message here is that there is a definite cause/effect relationship between our research and technology programs, our technology development demonstration programs and our ability to continue to capture a large share of the world's huge aeronautic business--and indeed, our ability to provide security for the nation's future. The current level of NASA's aeronautics program can be categorized as weak and anemic when one examines the enormous technology and worldwide business opportunities that exist--five critical technology areas were identified and discussed in some detail. The natural progression of technology research to technology development demonstration to operational prototype is not provided for in the current budget process. We strongly recommend a strengthening of support for the NASA Aeronautics Program in FY 86. This strengthening should be viewed as an intelligent investment in the country's future--an investment that will yield many-fold returns.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. Dr, Krone, you highlighted five areas in which the AIAA believes there should be increased emphasis in aeronautical research and technology development. Does this assume continued funding of all other programs at current or proposed levels? If the Committee were forced to make offsetting reductions to accommodate part or all of your recommendation, where would you suggest we look first?

Answer. The five areas suggested for increased emphasis (funding) were selected based on the judgment that the dollars saved in FY86 by funding them at a suboptimum level (currently planned) would result in a far greater loss in dollars in future years. This loss in revenue will be directly related to the loss of capability and performance of the future vehicles when compared to the foreign competition. This judgment assumes other aeronautical program areas are maintained at the currently planned level and that this level is near optimum. The aeronautics portion of the NASA budget is so low (7.9% of the total) that any significant reduction of another aeronautical program area would cause a similar reduction in competitive posture. In light of the critical economic need to maintain our international sales of airplanes, helicopters and missiles I would recommend no cuts in the aeronautics portion of the NASA budget—7.9% of the total is already far too low—and suggest the reductions be taken from the other 82.1% of the budget.

Question. With each of the five program areas in which you suggest increased emphasis, would you please provide specifics in terms of dollar amounts you think are necessary?

Answer. The current budget environment makes it difficult to recommend increases; however, the situation is best described by "we cannot afford not to." Therefore, I will recommend the following increases over the 1986 planned levels:

(1) In-house wind tunnel support for correlation of numerical codes—20 percent;
(2) Rotorcraft—15 percent;
(3) Advanced Structural materials—10 percent;
(4) Hot Section research—10 percent;
(5) Hypersonics—10 percent.

In my opinion, an additional $50 M would be a good investment in the future.

Question. You discussed the need for strengthening the NASA aeronautics program in Fiscal Year 1986. By the term "strengthening" do you mean solely increased funding levels? If you are suggesting more than this, what specific actions would you recommend?

Answer. The term "strengthening" refers to an increased level of effort that requires increased funding levels. The in-house (personnel or facilities) and the out-house contract work both benefit from increased funding.

Question. Dr. Krone, you advocate increased emphasis with respect to the NASA budget on hypersonic research and technology capabilities. What specific benefits would be derived from increased work by NASA in this area?

Answer. I believe the long hiatus (10-15 years) we have taken in hypersonics will catch up to us if we don't start an immediate rebuilding. The potential for safe and economic hypersonic transportation is beginning to appear on the horizon. The aerodynamic propulsion, materials and control technologies will blend to draw a hypersonic transport out of the realm of the impractical. Eventually, large hydrogen burning vehicles will be more practical than smaller, slow hydrocarbon burning vehicles for transcontinental ranges. The second generation shuttle and the trans-atmospheric vehicle will also benefit directly from an increased level of hypersonic technology.

Senator

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS

Question. Dr. Krone, you highlighted five areas in which the AIAA believes there should be increased emphasis in aeronautical research and technology development. Does this assume continued funding of all other programs at current or proposed levels? If the Committee were forced to make offsetting reductions to accommodate part or all of your recommendation, where would you suggest we look first?

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Senator **GORTON**. You did very, very well.

Dr. Shank.

Mr. **SHANK**. Thank you, Senator. I appreciate the opportunity for United Technologies and it's Pratt & Whitney Group to appear before your committee. We have reviewed the 1986 fiscal year aeronautics authorization request. We certainly support it, and we particularly support the aeronautics budget.

We are very pleased that the administration, even in these times of fiscal restraint, has seen fit to continue support for NASA aeronautics. We are particularly pleased that the Government plans to continue support of the turboprop program. We think this will help furnish the technology for even more fuel-efficient propulsion systems for aircraft in the 100- to 120-passenger size that will enter service in the early- to mid-1990's.

There is no question that superiority in propulsion is one of the principal keys to superiority in aeronautics, and we do want to say that if the Nation is to sustain its propulsion superiority over the long term, we believe that for the future not necessarily this year, NASA should initiate a program that supports new component technologies for gas turbine engine applications ranging from the subsonic regime through the high supersonic arena of the future.

I will not delineate the details here. They are contained in my written statement. Let me just say that there are several areas where critical propulsion technologies offer potential for large payoffs, and these technologies should be explored.

I think history demonstrates that the great innovative aircraft that have been developed like the initial commercial jet aircraft, the Boeing 707, or DC-8 or the wide bodies, would never have come into being if the right engine had not come along in time to propel it.

Traditionally, NASA has provided a stimulus to the aeronautical industry by supporting very high risk proof-of-concept work. Its resulting contributions to aeronautics technology have benefited both commercial and military of aviation.

As Mr. Krone has said, aeronautics is a relatively small percentage of the NASA budget. After NASA proof-of-concept technology is available, industry never has hesitated to apply it to assess development risks and then channel very large development resources where they would do the most good. Certainly over these past decades, the American aeronautics industry has not lost its willingness to accept the responsibilities associated with the development of high technology, advanced concepts, and advanced products for the market.

After NASA has done its proof of concept work, industry invests at very substantial risk more than 10 times as much of its own money to develop and market new products using the new technology. And, as has been pointed out by previous speakers, the payback to the country is enormous, exceeding hundreds of time NASA's original investment.

In conclusion I would like to say that if the United States is to sustain its position of superiority in aeronautics, then we must to maintain our world leadership in both civil and military aeronautics technology. NASA plays a vital role in this leadership. We support it fully.

Thank you.

[The statement follows:]

STATEMENT OF DR. M.E. SHANK, DIRECTOR, ENGINEERING TECHNOLOGY ASSESSMENT, UNITED TECHNOLOGIES CORP., PRATT & WHITNEY GROUP

On behalf of United Technologies Corporaton and its Pratt & Whitney Group, I'd like to thank you for the chance to discuss the National Aeronautics and Space Administration's aeronautics program.

At Pratt & Whitney, we design, develop and market commercial and military aircraft engines on a worldwide basis. We believe it's in our nation's interest to maintain its world leadership in aeronautics. To do so, we must have a superior technology base. Traditionally, NASA has contributed to this technology base to the benefit of both military and commercial aviation.

We've reviewed the NASA Fiscal Year 1986 Aeronautics Authorization request, and we support the proposed aeronautics program, particulalry the aeronautics propulsion budget.

It's gratifying that, during these critical times of necessary fiscal restraint, the Administration wants to continue to support NASA aeronautics. Unquestionably, this support is vitally important if the United States is to sustain the "proof-of-concept" technology that has been so beneficial in helping to keep our aeronautical products ranking second behind agriculture in exports.

We're especially pleased that the government plans to continue support of the turboprop program. We think this will help furnish technology for even more fuel-efficient propulsion systems for aircraft in the 100- to 120-passenger size that will enter service in the early to mid-1990's.

There's no question that superiority in propulsion is a key to superiority in aeronautics. If this country is going to sustain its propulsion superiority over the longer term, we think that NASA should initiate a program that supports new component technologies for gas turbine engines for applications ranging from the subsonic regime through the high supersonic arena of the future.

Indeed, there are several areas where critical technologies offer potential for large payoffs, and these technologies should be explored. For example, NASA should be studying advanced compression systems operating at high rotational speeds and high pressure ratios.

It should be trying to improve even further the understanding of the hot section environment, as an extension of its turbine engine Hot Section Technology (HOST) program.

There should be work on developing new materials—materials with high strength and temperature capabilities, including advanced composites having greater stiffness, toughness, better strength-to-weight and the ability to withstand higher temperature.

There also should be a program for advanced computational fluid dynamics research.

Commercial engines for the 1990s and beyond, whether turbofan or turboprop, will have very high bypass ratios for high propulsive efficiency. In a high engine bypass very large quantities of air move around the engine core, while relatively small amounts of air actually go through the compression and combustion process. In the case of the turbofan, we'll need advances in nacelle technology.

Such a component program will have a significant effect on propulsion for both commercial and military aircraft. Ultimately, it will mean better performance, improved operability, and higher durability—which in turn mean lower cost and higher reliability.

Without these 1990's technology programs, the full potential for obtaining high-performance, fuel-efficient gas turbine engine will not be reached.

Traditionally, NASA has provided a stimulus to the aeronautical industry by supporting high-risk, proof-of-concept work. Its resulting contributions to technology in aeronautics have benefited both commercial and military aviation.

The funds our government invests in aeronautics through NASA represent only four to five percent of the NASA budget.

Once proof-of-concept technology is available, industry is able to assess development risks and then channel its own development resources where they will do the most good.

American industry has not lost its willingness to accept the responsibilities associated with the development of high technology, advanced concepts and advanced products for the market.

After NASA has done proof-of-concept work, industry has to invest, at substantial risk, more than ten times as much of its own money to develop and market new products using the new technology.

The payback to the country is enormous. Ultimately, the sale of these new products worldwide can exceed hundreds of times NASA's original investment.

The NACA/NASA long-term partnership with industry in aeronautical research and technology has created an aviation industry inour country whose total output last year—based on preliminary data—exceeded $42 billion, and there was a positive trade balance in aerospace of $10 billion.

If the United States is to sustain this position, we must maintain our world leadership in civil and military aviation technology. NASA aeronautics plays a vital role in this leadership.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. Dr. Shank, your testimony also indicates that NASA should extend its HOST program. Just how long should this program continue as a NASA-sponsored program. Dr. Shank, could you comment on the appropriateness of the $5.2 million allocated for the HOST program in this budget request?

Answer. Presently the HOST program is scheduled to end in FY 89. The program should be continued through FY 91 to allow new and existing projects to be completed to the point industry can apply the results in new engine designs. The program funding has averaged just over $5.0M per year since the program was initiated 5 years ago, reaching a peak of $9.2M in FY 85. Present indicators are that the program, which has been held in highest esteem throughout the gas turbine industry, will be phased out before half of the funds originally envisioned for HOST are realized. A funding level in the $7-10M range for FY 86 would allow the program to continue at a level that will assure that all the potential benefits of this program are realized, providing about $10M/year are made available through completion in FY 91. Therefore, we believe the $5.2M presently being considered for the HOST program in the FY 86 budget should be increased.

Question. Dr. Shank and Mr. Kirchner, the National Research Council report on the Competitive Status of the U.S. Civil Aviation Manufacturing Industry recommends that NASA reconsider its activities relative to the validation of new technological advances for certification and public acceptance. Is NASA conducting an appropriate amount of "technology validation"? If not, how might NASA incorporate additional "technology validation" into its present and future programs? How and to what extent is additional technology validation likely to affect NASA's aeronautical research and technology funding levels?

Answer. NASA is conducting the appropriate amount of technology validation in view of the present level of NASA funding. In conducting this type of activity the expenditures are considerably higher due to the procurement of the necessary experimental hardware to conduct verification testing. In order for NASA to increase the amount of technology validation in the future the funding level would have to be substantially increased. Use, where appropriate, of available hardware from industry may be an approach to reducing the costs of this type of testing. A joint industry/NASA partnership will foster a joint sense of program ownership between NASA and industry and would tend to ensure that the technologies being pursued are relevant to the future needs of industry.

Question. On Monday, the White House Science Advisor released a report on national aeronautical R&D goals, one of which is related to subsonic transport. One of the technologies mentioned in this report which would support subsonic aeronautics is all-composite primary structures. Yet the Administration terminated NASA's Advanced Composite Structures Technology program. Can industry develop the relevant composite technologies in support of this subsonic transport goal? Can industry accomplish the same technology objectives as the NASA program related to primary composite structures, only at a slower pace? What is the appropriate role for the government if this technology is to support a national aeronautical goal? How can the $24 million investment to date in NASA's Advanced Composite Structures program be maximized.

Answer. NASA's Advanced Composite Structures Program is directed to all composite primary structures for subsonic transport aircraft and comments regarding this program should be made by the aircraft manufacturers. We at P&W do have an interest in composite materials, especially for large engine case structures and for propulsion system nacelles. We believe that information generated from the Composite Structures Technology Program will be applicable to propulsion in many instances.

Question. The National Research Council report also suggests that it would be in the best interests of NASA and the U.S. aircraft manufacturers to assign a higher priority to the collection and evaluation of foreign technology. Should we be doing more in this area? On the other hand, is our technology too available to our competitors?

Answer. At present the Air Force has an organization dedicated to the evaluation of foreign technology. If NASA is to initiate such an activity, it will need a similar dedicated organization. If such an organization were established, careful coordination with the Air Force would be required to prevent duplication. However, if a NASA organization of this type were to concentrate on the more fundamental aspects of foreign technology, an area where NASA excels, it would be a positive move.

Concerning dissemination of NASA technology abroad, the results of NASA research are readily obtained by any U.S. addressee from the National Technical Information Service (NTIS) in Springfield, VA. We believe that this system should be reviewed.

Question. The White House report on national aeronautical R&D goals also mentions goals related to supersonic cruise transport, and the White House Science Advisor said that, while the Administration has made no commitment to a supersonic transport, it is laying the groundwork, both in NASA and DOD, in the fundamental supporting technologies. Is NASA adequately supporting the technologies that will lay the groundwork for a supersonic transport? If not, what should NASA do differently to support this goal.

Answer. NASA, due to budget limitations, is not supporting adequately the technologies that will lay the groundwork for a supersonic transport propulsion. Prior to 1981 we participated in NASA sponsored technology work which defined a propulsion system called the Variable Stream Control Engine for supersonic transport applications. Since the termination of these propulsion activities in 1981 we have not participated in any active SST endeavors. To establish a supersonic propulsion technology program will require a substantial increase in NASA funding.

Question. The third goal in the White House report on national aeronautical R&D goals concerns transatmospheric transport. How soon is there likely to be a national requirement for such a capability—will it be largely civil or military? How much would it cost to develop this capability and over what period of time? Do NASA's present and projected budget requests adequately support these transatmospheric technologies?

Answer. It is difficult to determine at this time if the eventual application of the transatmospheric transport will be civil or military since the technology has not been fully explored. Initially, it would be a military application. It would require an extensive period of time to develop a transatmospheric capability. Certainly if this requirement is to be met by the turn-of-the-century, funding for the propulsion technology required should be initiated now. This will require a many-fold increase in the NASA Aeronautics budget. The exact level can be determined only after detailed studies are conducted. NASA's present and projected budget requests are not adequate to support these new technologies in a meaningful way.

Question. The White House Science Advisor, when questioned about an increase in NASA's aeronautical budget to support these three national aeronautical R&D goals, said that he did not foresee a significant increase. Can we make significant advances in subsonic, supersonic and transatmospheric aeronautics as national goals with a NASA aeronautics budget that continues to grow at a rate not greater than inflation.

Answer. It is difficult to envision the implementation of the new White House National Aeronautics Policy that would support development of a new generation of subsonic transports, a Mach 3 transpacific supersonic transport and transatmospheric vehicle without very substantial increases in NASA's future aeronautical budgets. A national priority must be established, especially in the high speed area, before the research and development resources required for these programs are committed.

Question. What kind of increases in NASA's aeronautical R&D budget are necessary to permit these goals to become a reality? What can industry do to support these goals?

Answer. NASA's aeronautical R&D budget would have to be increased at least two to three times its present level on an ongoing basis to do the R&T base technology required for these new systems. For further proof-of-concept flight demonstration, a detailed study would be required for each application. A recent report dated Nov. 1984 prepared by NASA for the Committee on Science and Technology House of Representatives on a "Focused Hypersonic Research Program" indicated the total cost of such a program is estimated to be $1033M to $1100M over 15 years.

If NASA funds the R&T base programs, industry will be stimulated to focus inhouse resources to complement the funds provided thereby obtaining synergism between industry and NASA and application of industrial funding after proof-of-concept has been obtained and a market determined.

Question. With one industry team planning to conduct in 1986 a flight test of its counter-rotation turboprop technology, does this in any way reduce the justifications for NASA conducting a flight test of the single-rotation configuration, after the industry-sponsored test?

Answer. Justification for NASA conducting a flight test of the single-rotation configuration is based on the long term, phased R&T approach adopted by NASA. This will culminate in a demonstration of the broad generic technologies and validation of design systems which apply to all propfan powered transports of the future. The technology necessary to obtaining the required propeller efficiency and structural reliability, cabin and far field noise levels, and low-drag aerodynamic installation will be verified in the 1987 flight demonstrations. Since NASA has invested ten years of R&T work in developing the propfan it would be short-sighted to abandon this program.

Question. Year after year, Congress and presumably NASA is faced with the question of deciding at what point NASA should no longer conduct certain work and industry should assume the responsibility. We all know that this decision is based on assessments of risks, lead-time of payoffs, and facilities, but could you expand on this and share with us just how this decision is made.

The National Research Council report suggests that it would be in the best interests of NASA and the U.S. aircraft manufacturers to assign a higher priority to the collection and evaluation of foreign technology. To what extent are we presently taking advantage of the available data of our competition? How can we improve our efforts in this area.

Answer. To meet today's economic and competitive pressures industry must focus its efforts on new product lines. Without adequate support by NASA to provide far term fundamental technology, industry will be at a competitive disadvantage. Development of a new aircraft engine can cost approximately a billion dollars. After NASA has established proof-of-concept for advanced technology industry then can assess risk and apply this technology in the development of new product lines. NASA's role is to develop proof-of-concept with suitable verification, and selective demonstration of technology. Development beyond this is appropriate for industry.

Question. The National Research Council report, to which I referred in my opening statement, recommends a "reexamination of the research and technology development activity in support of civil aviation in NASA, in light of the changing competitive environment and the technical opportunities noted in this study". Could you share with us your thoughts on this recommendation? To what extent is NASA likely to conduct this "reexamination"?

This report also recommends that NASA reconsider its activities relative to the validation of new technological advances for certification and public acceptance. Since technology validation is within NASA's charter and because most industrial firms lack the resources to undertake uncertain work of this nature, should NASA reconsider its role relative to technology validation?

Answer. The Aeronautics and Space Engineering Board (ASEB) of the National Research Council conducted a workshop on the role of NASA in aeronautics. The conclusions and recommendations of this workshop are contained in the report published by the National Research Council (National Research Council Report, "NASA's Role in Aeronautics: A Work-shop", Volume 1 Summary, National Academy Press, Washington, D.C. 1981). P&W participated in this workshop and concurred with the findings and recommendations. This report is still valid, and should be considered in any future reexamination of NASA's role.

ASEB, with active participation by NASA, is now completing a "Year 2000" study to establish its future role. Since NASA is fully aware of the increasing competitive threat from abroad, there is no doubt that this consideration is included in the study.

Question. I understand that NASA has $5 million in this budget request for planning related to the development of an Altitude Wind Tunnel at Lewis Research Center, a development that could cost as much as $160 million. What unique capabilities woud this Wind Tunnel provide that do not presently exist in Air Force tunnels or other facilities?

To what extent will the size of the test section of this tunnel limit the tunnel's ability to test large-size aircraft/propulsion systems, prop-fans, or helicopter rotors?

What are the projected annual operating costs for the Altitude Wind Tunnel?

Do you believe that the consensus of industry supports an investment of $160 million and annual operating costs of this magnitude for the Altitude Wind Tunnel at Lewis Research Center?

Answer. We understand that the Subcommittee on Transportation, Aviation and Materials of the House Committee on Science and Technology chaired by Honorable Dan Glickman appointed a government/industry team of experts to conduct an examination of this question. We suggest the Senate Subcommittee on Science, Technology, and Space secure a copy of the ad hoc Subcommittee report "Assessment of the Altitude Wind Tunnel at NASA Lewis Research Center" as well as the NASA response to the report.

Senator GORTON. Thank you, Mr. Shank.

Mr. Kirchner, welcome from home.

Mr. KIRCHNER. Thank you, Mr. Chairman.

These are lean budget days, as we know, and we appreciate the job the Senate and the House is doing in trying to work on tight budgets and still support the goals of NASA. I personally believe that the problem is one of priorities rather than total budget, because we know that the total budget is constrained to certain limits, and we prefer to argue the case about priorities within those constraints.

We certainly believe that the order of magnitude of the $354 million proposed by the administration for the aeronautics budget is a tight and lean budget. We think that if it gets cut lower than that, we are going to have to dig into some priorities that are truly important.

I would like to take the opportunity in these few minutes just to comment on a couple of the more important things that we see within that budget and also, incidentally, things that you yourself have just brought up.

In the area of composites, we agree that, in the situation where we have such a tight budget, NASA should back off from funding very large composite components. It is very expensive. Perhaps industry should take more of a load in that regard.

On the other hand, as Dr. Martin mentioned, he is picking basic composite technology work, and we subscribe to that. But we do believe that there remains a lot of technology work to be done, not on the large components, but on the development of the technology itself.

There are thermoplastics. There are advanced techniques and innovative design, tolerance testing, and many areas where, now that we free up the budget from large components, we can get into more basic technology. And my own personal opinion is that it should be somewhat larger than the $3 to $5 million effort NASA presently plans. It should be at least twice that.

And I think in Dr. Martin's inquiries to industry, industry will respond with a lot of very good ideas that will help develop a good composites technology program.

I would like to point out that the technology of components has led us to a point where, although there is a good potential for weight saving and efficient design, it is still a very costly process and we are going to depend on innovative technology, advanced design techniques, and manufacturing technology in order to bring these costs down.

I would like to address my comments to the advanced turboprop program for a moment. I believe one of NASA's problems is that it has to make a long-range program plan, where such a complex development of technology is involved.

In this regard, we often get locked into a program where, as time goes on, technology catches up and passes it by or points toward certain other emphasis. As you pointed out in your comments, Mr. Chairman, there are advanced counterrotating activities going on in industry right now, and I believe that most of the people dealing in concepts for the future are dealing more in these advanced concepts than they are in the areas where NASA's program has emphasis; flight testing in NASA's case is in fiscal 1987.

There are industry tests going on in fiscal 1986 which we believe are at least more advanced. Now, I must commend NASA on getting into participation in some of those programs, and they have done that. They have been flexible enough to get into those programs, but I believe that there is more they could do. If we are going to speak about priorities, I again would emphasize that the priorities of the more advanced technology and quicker programs would be a higher priority than those of programs of longer range, slower, and less technology.

There are things that can be done. For example, the advanced program going on in industry is rudimentary. There are a lot of things left to be tested and worked on that are not being planned by industry right now that could reduce the noise levels, provide better understanding of the technical interaction of counterrotating propellers, develop the design of propeller blades for high cruise MACH—numbers for counterrotating designs. The study of relative rotor sizes—front versus aft—for noise purposes, efficiency purposes, and variations of other parameters that can be attacked that are not planned because of the total cost, would all be useful additions to the turboprop technology base.

These are things that I believe are examples of things that can be done by NASA. Those are the two most important things that I would like to point out.

Thanks. My time is up.

[The statement follows:]

STATEMENT OF MARK KIRCHNER, DIRECTOR OF ENGINEERING TECHNOLOGY FOR THE BOEING COMMERCIAL AIRPLANE CO.

I am Mark Kirchner, Director of Engineering Technology for The Boeing Commercial Airplane Co., representing The Boeing Company, a major producer of aerospace products. It should be noted that I have participated in reviews of NASA programs as a member of the Aerodynamics Subcommittee to the NASA Aeronautics Advisory Committee, and as a member of the Congressional Advisory Committee on Aeronautics to Congressman Glickman's Sub-committee: Transportation, Aviation and Materials. Today I am representing the views of The Boeing Company.

The Boeing Company appreciates the invitation to appear here today to present our comments on the proposed FY '86 NASA budget and provide an assessment of the administration's budget in respect to the national aeronautical goals. The invitation is a timely one.

The Boeing Company has just completed studies of market requirements for future products, and has concluded that new aircraft development must offer significant improvements in operating cost and fuel efficiency at competitive manufacturing cost. For a free enterprise competitive society such as ours in the United States, the question is "How do we achieve high technology breakthroughs in the face of cost escalation"? There can be only one answer. We must achieve significant product productivity increases that will make the high-technology breakthroughs affordable.

The aeronautical policy established earlier this week by President Reagan and announced by Dr. Keyworth provides goals for creating a comprehensive Research and Development (R&D) policy; a policy that assign a high national priority to R&D; that encourages more effective cooperation among the government, academic and industry communities; and on that stimulates industrial R&D aimed at the creation of superior products for the marketplace. A positive focus on America's future is required by all elements of the aeronautical community.

NASA's role and contribution to aeronautics has been, and should continue to be, Research and Technology (R&T) development. NASA has made significant contributions to the aeronautical field and NASA personnel can justly take pride in their programs. Unique, high-technology facilities and equipment, combined with the first-class research and technical talent at work in those facilities represent a national resource that cannot be duplicated by industry.

In the FY '86 budget request the aeronautical role of NASA is understated, especially if the newly established aeronautical policy is to be implemented. There is an absence of important programs and substantial funding deficiencies exist in others. Even with extreme overall budget constraints NASA is broadly pursuing the correct path in its aeronautical activities.

The Boeing Company has reviewed more that 100 separate proposed NASA aeronautical programs. Each program has merit. However, in some program areas there appeared to be imbalances in funding and timing. Specific programs or facility needs that we would like to comment on are the Large Composite Primary Aircraft Structure Program, the Viscous Drag Reduction Program, the Advanced Turboprop Program, the Numerical Aerodynamic Simulator Program, the Altitude Wind Tunnel Facility, the 12 ft. Low Speed Pressure Wind Tunnel Facility, an Integrated Test Facility for Advance Research Aircraft, a "Quiet Wind Tunnel" Facility and Fly by Wire/Light (FBW/L) Control Systems.

LARGE COMPOSITE PRIMARY AIRCRAFT STRUCTURE (LCPAS) PROGRAM

Advanced composite structures provide industry the opportunity to develop aircraft with significant weight reductions which in turn convert to significant fuel savings. In the FY'86 budget considerations, the development of LCPAS was cancelled. With the imposed budget constraints, perhaps industry should assume a larger role in developing these large components. Basic companion R&T activities and ones previously deleted to help fund the LCPAS Program should be continued by NASA. Five to seven million dollars should be allocated for this purpose during FY '86.

Typical examples of these R&T efforts are:

Thin skin lightly loaded structure methodology to complement NASA's successful development of high performance thick wing type structure.

Toughened materials and damage tolerance methodology to increase efficiency, reduce weight and maintenance costs.

Structural analysis and predictive allowables methodology to reduce test costs.

Service environment response to achieve long service life and reduce maintenance.

Innovative design concepts with attendant testing.

VISCOUS DRAG REDUCTION

Laminar flow represents a major opportunity for drag reduction. To date, operational and economic uncertainties have caused delays in its application. Current flight test programs involving the NASA-owned Jet Star and the F-14 should be continued. Since flight validation will be necessary before a commitment could be made on a major program, flight tests on commercial type aircraft such as the DC-9, B-727 and B-767, should be studied to determine potential NASA and industry roles. Also turbulent boundry layer drag reduction techniques, such as those studies conducted at Langley Research Center, should be pursued aggressively in the laboratory and in flight.

ADVANCED TURBOPROP PROGRAM (ATP)

Advanced turboprop engines offer the potential of 15 to 30 percent savings in aircraft block fuel relative to advanced turbofan engines. ATP is developing new technology for highly-loaded, multi-bladed propellers for use at Mach 0.65 to 0.85 and at altitudes compatible with air transport system requirements. The major portion of NASA funding supports a single rotation, wing-mounted propeller concept and includes flight test on a Gulfstream II aircraft in FY'87.

In the meanwhile, industry with some NASA support has developed a highly-efficient advanced technology counter-rotation concept. Ground tests are to be conducted FY '85 and flight test is planned for FY '86. It would be timely and productive to have additional NASA support for this concept. Research studies investigating the effect of blade variations and stage configuration on noise and vibration are needed.

In general, The Boeing Company supports the objectives of the ATP, but recommends that new priorities be established and that a further evaluation of the program elements be carried out to ensure an overall balanced program.

NUMERICAL AERODYNAMIC SIMULATION (NAS) PROGRAM AT AMES RESEARCH CENTER

The methods currently utilized by industry to develop complex configurations involve a lot of "cut and try" techniques which are expensive since they imply extensive testing. The NAS program addresses development of computational processes for handling complex geometrics in regimes dominated by viscous effects. Benefits include rapid response to design requirements, extensive optimization before wind tunnel testing and reduced risk in meeting design goals. The FY '86 budget request emphasizes this and we support it.

ALTITUDE WIND TUNNEL (AWT) FACILITY AT LEWIS RESEARCH CENTER

Rehabilitation of the AWT enhances the nations test capability and provides in one location some of the capabilities of other facilities plus some new features. Currently envisioned developments by industry are not dependent on the AWT. Given extreme budget constraints and limited benefits, the issues are affordability, operating and maintenance cost over a period of time.

12 FT. LOW SPEED PRESSURE WIND TUNNEL AT NASA

This facility was designed and certified for testing at six atmospheres. Due to defects found in welds, the facility has been derated several times and has a projected life of one year for testing at four and one half (4½) atmospheres. The principal use of the facility is the definition of maximum coefficient of lift versus Reynolds Number and Reynolds Number effects at high angle of attack. Use by DOD and industry has resulted in a backlog of work. We endorse the restoration and recertification of this facility at the full six atmospheres.

INTEGRATED TEST FACILITIES (ITF) AT NASA AMES-DRYDEN RESEARCH CENTER

During the development of the 757/767 aircraft, The Boeing Company committed to an integrated test facility to develop, test and evaluate the Flight Management System (FMS). The FMS is a complex, highly integrated system consisting of several major subsystems.

Our appraisal of the programs currently underway or being proposed at Dryden are significantly more complex. They involve test vehicles with highly unstable characteristics and complete reliance on fly-by-wire systems for stability and control. If save and timely test programs are to be accomplished, a sophisticated test facility is necessary and should be considered in future funding.

"QUIET WIND TUNNEL" (QWT) REQUIREMENTS

Flight simulation and wind tunnel testing of noise sources has become a continuing technology development requirement. The Europeans recognized this requirement and have developed major wind tunnels. An example of this type of facility is the wind tunnel commonly referred to as the DNW (Duits-Nederlandse Windtunnel) in the Netherlands.

The DNW was designed to integrate both aerodynamic and acoustic test requirements, to have a very low background noise level and to be of a size to permit testing of turboprops, helicoper rotors, and airframes. However, it is expensive to use, requires foreign travel and could involve exposure of classified and/or proprietary testing.

The United States needs a national "QWT" facility. We recommend future consideration be given to this type of facility and believe the first task is to identify existing candidate wind tunnels to determine the feasibility of modifying one.

FLY BY WIRE/LIGHT (FBW/L) CONTROL SYSTEMS

FBW/L presents an opportunity to reduce the operating costs of future aircraft. The challenge is that at this time the U.S. technology required to ensure highly reliable FBW/L does not exist. Evaluation techniques and tools, design criteria, and reliability concepts must all be established prior to consideration for use on commercial aircraft. The foreign aeronautical community is proceeding with development of FBW, and plan to have this technology implemented on their future aircraft. To remain competitive the U.S. should plan to address this technology. We recommend that FBW/L be considered in next year's budget requests.

SUMMARY

In conclusion, The Boeing Company believes the proposed FY '86 NASA budget is lean, but manageable. Meaningful work will be accomplished and will provide a basis for expanding the R&D necessary achieve the goals of the new National Aeronautical Policy.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. Mr. Kirchner, the National Research Council report on the Competitive Status of the U.S. Civil Aviation Manufacturing Industry recommends that NASA reconsider its activities relative to the validation of new technological advances for certification and public acceptance.

Is NASA conducting an appropriate amount of "technology validation?"

If not, how might NASA incorporate additional "technology validation" into its present and future programs?

How and to what extent is additional technology validation likely to affect NASA's aeronautical research and technology funding levels?

Answer. NASA's role has been defined by Administrative policy is generally accepted by the aeronautical community. Part of this role is technology validation, and NASA's contributions are very significant to public acceptance of new technology. The Boeing Company believes NASA has provided technical validation consistent with its defined role.

Validation data may be generated in either or both the R&T development and demonstration phases. NASA could achieve additional technology validation by expanding its role in the demonstration phase. This expansion would require additional funding and would not be productive if done at the expense of basic R&T development. The Boeing Company believes that maintaining the existing NASA's role is proper.

Question. On Monday, the White House Science Advisor released a report on national aeronautical R&D goals, one of which is related to subsonic transport.

One of the technologies mentioned in this report which would support subsonic aeronautics is all-composite primary structures. Yet the Administration terminated NASA's Advanced Composite Structures Technology program.

Can industry develop the relevant composite technologies in support of this subsonic transport goal?

Can industry accomplish the same technology objectives as the NASA program related to primary composite structures, only at a slower pace?

What is the appropriate role for the government if this technology is to support a national aeronautical goal?

How can the $24 million investment to date in NASA's Advanced Composite Structures program be maximized?

Answer. The Boeing Company has been involved with composite structure since the early 1970's. Company resources and development contracts from NASA and other government agencies have funded this work. NASA sponsored research was instrumental in the decision by the Boeing Company to expand the use of composites in the 757/767 airplanes.

The elimination of NASA funds for on-going Advanced Composite Primary Structures (ACPS) may delay Boeing's use of primary structure composites for new generation aircraft now under study especially in the fuselage. Other complementary government contracts and Boeing efforts will continue. It should be noted that the major thrust of the Boeing-funded effort involves design and manufacturing studies relative to reducing the production costs.

The Boeing Company believes that NASA should continue to focus on the basic R&T development to ensure the establishment of the required technical data. Areas of interest include:

Thin skin lightly loaded structure methodology to complement NASA's successful development of high performance thick wing type structure.

Toughened materials and damage tolerance methodology to increase efficiency, reduce weight maintenance costs.

Structural analysis and predictive allowable methodology to reduce test costs.

Service environment response to achieve long service life and reduce maintenance.

Innovative design concepts with attendant testing.

The investment of the $24 million dollars may be maximized by NASA for the ACPS program by focusing on the basic R&T data base requirements and by providing a forum for the exchange of information.

Question. The National Research Council report also suggests that it would be in the best interests of NASA and U.S. aircraft manufacturers to assign a higher priority to the collection and evaluation of foreign technology.

Should we be doing more in this area?

On the other hand, is our own technology too available to our competitors?

Answer. The policies of competing nations place a high priority on the collection and evaluation of technology. Compared to these nations, U.S. policies reflect a lower priority and the technical interchange may favor the competing nations. The Boeing Company does not believe that increasing the responsibility of either NASA or the private sector will have a beneficial effect until other actions are taken. We feel that the U.S. technical, economic and defense interest would be better served by first bringing cohesiveness to the various and sometimes conflicting policies. Until such steps are taken, the collection and assessment method will remain largely inadequate.

Question. The White House report on national aeronautical R&D goals also mentions goals related to supersonic cruise transport, and the White House Science Advisor said that, while the Administration has made no commitment to a supersonic transport, it is laying the groundwork, both in NASA and DOD, in fundamental supporting technologies.

Is NASA adequately supporting the technologies that will lay the groundwork for a supersonic transport?

If not, what should NASA do differently to support this goal?

Answer. The current allocation of funding for NASA is not adequate for supporting the technologies that will lay the ground work for a supersonic transport. The FY '86 budget request was formulated prior to the establishment of the new National Goals for Aeronautics and reflects a minimum approach to aeronautical development. Additional funds will be needed to expand the research activities directly applicable to supersonic cruise type aircraft.

The Boeing Company believes the NASA-funded Supersonic Cruise Research program, which ended in 1981, provides a starting point for further advancement of the pacing technologies. Further, it is believed that the development program must include demonstration, including flight of the pacing technologies to determine synergetic effect. Technology readiness could probably be achieved in five years with an expenditure rate of 50–60 million dollars per year.

Question. The third goal in the White House report on national aeronautical R&D goals concerns transatmospheric transport.

How soon is there likely to be a national requirement for such a capability—will it be largely civil or military?

How much would it cost to develop this capability and over what period time?

Do NASA's present and projected budget requests adequately support these transatmospheric technologies?

Answer. Operational or mission requirements which lead to a transatmospheric transport are not adequately defined and it is too early, technologically speaking, to establish specific requirements. Envisioned uses suggest military requirements may determine the initial design requirements. Past history suggest 5 to 10 billion dollars over a 10–15 year period will be required. However, this estimate is very speculative due to the lack of requirements definition.

The proprosed NASA budget plan does not support the envisioned level of activity of exploratory research. It is recommended that NASA develop a single thread program to cover advanced supersonic, hypersonic and TAV technologies.

Question. The White House Science Advisor, when questioned about an increase in NASA's aeronautical budget to support these three national aeronautical R&D goals, said that he did not foresee a significant increase.

Can we make significant advances in subsonic, supersonic and transatmospheric aeronautics as national goals with a NASA aeronautics budget that continues to grow at a rate no greater than inflation?

What kind of increases in NASA's aeronautical R&D budget are necessary to permit these goals to become a reality?

What can industry do to support these goals?

Answer. There is no question that the current strategy for NASA aeronautical funding keeping pace with inflation, will be inadequate for U.S attainment of the stated goals in aeronautics. A real growth in the levels of R&T development directed toward all three goals will be required. Supplemental funding, maybe up to $150 million dollars per year, will be needed. A more definitive estimate of funding is dependent on the development and assessment of technology road maps.

It should also be noted that the aeronautical R&D goals report identified the need for cohesive R&D policies. The report made the point that increased funding was not in itself a solution so long as the U.S. maintains a "business as usual" attitude with respect to research growth impediments—research contracting procedures, lack of research continuity, regulatory constrains, and tax policies. It will require smart money and cohesive policies to create a dynamic and flexible capacity to exploit these goals.

Question. With one industry team planning to conduct in 1986 a flight test of its counter-rotation turboprop technology, does this in any way reduce the justifications for NASA conducting a flight test of the single-rotation configurations, after the industry-sponsored test?

Answer. The Boeing Commercial Airplane Company (BCAC) has committed to develop a modified 727 for research, development and demonstration of ultra bypass-ratio engines. This R&D tool has been offered to all engine companies as a supplement to their development programs. GE will be the first to develop and demonstrate an innovative concept of a counter-rotational turboprop engine. The role of the BCAC is to (1) conduct a preliminary design of an engine strut, (2) assist the manufacture of the strut, (3) assist in the testing to demonstrate the technology, (4) design and make required aircraft modifications, and (5) assist in the installation and test of the engine on a Company owned 727 flight test aircraft. The combined effort was initiated in 1983 and it should be noted that NASA has provided support to GE. Efforts are proceeding per the established plan and the key activities remaining are model test (Aug. 1985), full scale ground test (Aug. 1985 and Jan. 1986), and flight demonstration tests (July, 1986).

The NASA ATP is a broad based, multi-element effort. The program includes a flight test in 1987 of a single rotation concept. The technologies of both single and counter rotation concepts are of interest to the aeronautical field. The Boeing Company believes both concepts have the potential production viable.

Historically, proof-of-concept demonstrations provide a data baseline from which production decisions may be evolved. This evolution requires a data base of generic technical parameters which support the decision process for developing efficient designs. The Boeing Company believes additional parametric effort that is applicable to counter-rotational concepts would be timely and productive especially supported to determine the effects of blade variations and state configuration on noise and vibration.

Question. According to NASA's budget projections, NASA intends to terminate its Rotorcraft Systems Technology programs by FY 1988.

What is the justification for this action—will there no longer be an appropriate R&D role for NASA after FY 1987? It appears that the market share of our foreign competition is growing year by year—is this simply a trade issue.

Answer. NASA has traditionally supported "focused" demonstration programs such as tilt rotor (XV-15) and RSRA/X-Wing. The programs have finite lives and the funding requirements of the current programs in this category will, in fact, phase out by 1988. Potential new program starts are being studied in the current planning cycle and as appropriate will be recommended for implementation.

It should also be noted basic R&T development efforts are being conducted at the same time and a proposal to expand the R&T effort to include additional research in rotorcraft noise and vibration has been developed.

Question. The National Research Council report, to which I referred to in my opening statement, recommends a "reexamination of the research and technology development activity in support of civil aviation in NASA, in light of the changing competitive environment and the technical opportunities noted in this study".

Could you share with us your thoughts on this recommendation? To what extent is NASA likely to conduct this "reexamination"?

Answer. A re-examination of the R&T development activity in suport of civil aviation in NASA occurs each year, concurrent with the annual budget cycle. Members of industry participate in this re-examination through the committee and subcommittee structure of the NASA Advisory Council. In addition, special "work shop" sessions to review the appropriate role of NASA in aeronautics are held. An example is the work shop the National Academy of Sciences held in 1981 and more recently the effort by the Office of Science and Technology Policy to establish national aeronautical R&D goals. Ultimately, the future NASA role will evolve from the downstream activities needed to attain the new national goals.

Question. This report also recommends that NASA reconsider its activities relative to the validation of new technological advances for certification and public acceptance. Since technology validation is within NASA's charter and because most industrial firms lack the resources to undertake uncertain work of this nature, should NASA reconsider its role relative to technology validation?

Answer. NASA's role has been defined by Administrative policy and is generally accepted by the aeronautical community. Part of this role is technology validation, and NASA's contributions are very significant to public acceptance of new technology. The Boeing Company believes NASA has provided technical validation consistent with its defined role.

Validation data may be generated in either or both the R&T development and demonstration phases. NASA could achieve additional technology validation by expanding its role in the demonstration phase. This expansion would require additional funding and would not be productive if done at the expense of basic R&T development. The Boeing Company believes that maintaining the existing NASA's role is the proper course of action.

Question. Year after year, Congress and presumably NASA is faced with the question of deciding at what point NASA should no longer conduct certain work and industry should assume the responsibility. We all know that this decision is based on assessments of risks, lead-time of payoffs, and facilities, but could you expand on this and share with us just how this decision is made?

Answer. Generally, the decision to assume responsibility for certain work is made by industry when the perceived benefits exceed the perceived risks. At The Boeing Company a highly integrated effort among the technical, manufacturing and management functions is conducted. Professional experience is utilized to consider factors such as technical readiness, product operational requirements, marketing timing, costs and benefits.

Question. The National Research Council report suggests that it would be in the best interests of NASA and the U.S. aircraft manufacturers to assign a higher priority to the collection and evaluation of foreign technology. To what extent are we presently taking advantage of the available data of our competition?

Answer. The policies of competing nations place a high priority on the collection and evaluation of technology. Compared to these nations, U.S. policies reflect a lower priority and the technical interchange may favor the competing nations. The Boeing Company does not believe that increasing the responsibility of either NASA or the private sector will have a beneficial effect until other actions are taken. We feel that the U.S. technical, economic and defense interest would be better served by first bringing cohesiveness to the various and sometimes conflicting policies. Until such steps are taken, the collection and assessment method will remain largely inadequate.

Question. The second national aeronautical R&D goal of the recently-released report by the Office of Science and Technology Policy relates to supersonic transport. Dr. Keyworth said that, although the Administration has made no commitment to such an aircraft, it is laying the groundwork at NASA and at the Department of Defense.

How soon would we be able to respond to a call for a supersonic transport aircraft and at what cost to NASA and the DOD? How and to what extent does NASA's budget request support the fundamental technologies related to supersonic aeronautics?

Answer. The current allocation of funding for NASA is not adequate for supporting the technologies that will lay the ground work for a supersonic transport. The FY '86 budget request was formulated prior to the establishment of the new National Goals for Aeronautics and reflects a minimum approach to aeronautical development. Additional funds will be needed to expand the research activities directly applicable to supersonic cruise type aircraft.

The Boeing Company believes the NASA-funded Supersonic Cruise Research program, which ended in 1981, provides a starting point for further advancement of the pacing technologies. Further, it is believed that the development program must include demonstration, including, flight of the pacing technologies to determine synergetic effect. Technology readiness could probably be achieved in five years with an expenditure rate of 50-60 million dollars per year.

Question. Concerning the goal of transatmospheric aeronautics, how soon do you envision a national requirement for such a capability and what are the potential requirements for such a capability? How and to what extent does NASA's budget request support these fundamental technologies?

Answer. Operational or mission requirements which lead to a transatmospheric transport are not adequately defined and it is too early, technologically speaking, to establish specific requirements. Envisioned uses suggest military requirements may determine the initial requirements.

Development costs depend on specific requirements and since they do not exist, specific definitive cost estimates are very speculative. Past history suggest 5 to 10 billion dollars over a 10-15 year period would be required.

The proposed NASA budget plan does not support the envisioned level of activity of exploratory research. Also, a single thread program to cover advanced supersonic, hypersonic and TAV technologies should be developed.

Question. When asked if the Administration's new goals in aeronautical R&D would require an increase in NASA's aeronautical budget, Dr. Keyworth said that he did not foresee the need for an increase to support these goals. Can we realistically expect to achieve these goals without any significant increase in NASA's aeronautical budget? How can we accomplish these national objectives within a NASA aeronautical budget that grows only at a rate to keep pace with inflation?

Answer. There is no question that the current strategy, keeping pace with inflation, for NASA aeronautical funding, will be inadequate for U.S. attainment of the stated goals in aeronautics. A real growth in the levels of R&T development directed toward all three goals will be required. Supplemental funding, maybe up to $150 million dollars per year, will be needed. A more definitive estimate of funding is dependent on the development and assessment of technology road maps.

It should also be noted that the aeronautical R&D goals report identified the need for cohesive R&D policies. The point the report made was that increased funding was not in itself a solution so long as the U.S. maintains a "business as usual" attitude with respect to research growth impediments.—research contracting procedures, lack of research continuity, regulatory constraints, and tax policies. *It will require smart money and cohesive policies to create a dynamic and flexible capacity to exploit these goals.*

Question. I understand that NASA has $5 million in this budget request for planning related to the development of an Altitude Wind Tunnel at Lewis Research Center, a development that could cost as much as $160 milion. What unique capabilities would this Wind Tunnel provide that do not presently exist in Air Force tunnels or other facilities?

To what extent will the size of the test section of this tunnel limit the tunnel's ability to test large-size aircraft/propulsion systems, prop-fans, or helicopter rotors?

What are the projected annual operating costs for the Altitude Wind Tunnel?

Do you believe that the consensus of industry supports an investment of $160 million and annual operating costs of this magnitude for the Altitude Wind Tunnel at Lewis Research Center?

Answer. Rehabilitation of the AWT enhances the nations test capability and provides in one location some of the capabilities of other facilities plus some new features. Currently envisioned developments at The Boeing Company are not dependent on an AWT.

Given the extreme budget constraints and modest benefits, the issue is affordability. The Boeing Company assessment is that it would be low on the company priority list.

The AWT, with a 20′ test section, will permit rotors up to 15–16 feet to be tested. This represents a ½ or smaller scale of helicopter main rotors. This scale capability is better than other facilities, however, scaling of test results is still needed. Where it is felt that full scale test results are required, the NRC of Canada helicopter spray rig or the U.S. Army Helicopter Icing Spray System (HISS) permit such tests.

Studies are currently underway that will provide additional knowledge of test requirements for rotor icing. One such activity is an FAA sponsored program to develop program plan to define the techniques appropriate to icing certification in lieu of full scale, natural icing flight testing.

Question. On Monday, the White Science Advisor, Dr. George Keyworth, released a report that proposed national aeronautical R&D goals in subsonic, supersonic, and transatmospheric transport.

Dr. Keyworth said that in the area of subsonic transports, all-composite primary structures would be brought to maturity in the 1990's.

It is possible to develop this composite technology in support of the subsonic transport goal in spite of the Administration's termination of NASA's Advanced Composites Structures Technology program—can industry fulfill this technology objective or should the Administration continue NASA's Composite Structures program?

Is NASA prepared to request funding for the Advanced Composites Structures Technology in fiscal year 1987 in light of the recently-released national goals for aeronautical research and development, or does NASA consider this program terminated?

How have the assumptions and justifications for the Advanced Composites Structures Technology program changed from two years ago, when you initiated this program—what is different now than then?

How do you plan to maximize the utility of your $24 million investment to date in this program?

Answer. The Boeing Company has been involved with composite structure since the early 1970's. Company resources and development contracts from NASA and other government agencies have funded this work. NASA sponsored research was instrumental in the decision by The Boeing Company to expand the use of composites in the 757/767 airplanes.

The elimination of NASA funds for on-going Advanced Composite Primary Structures (ACPS) may delay Boeing's use of primary structure composites for new generation aircraft now under study especially in the fuselage. Other government contracts and Boeing efforts will continue despite the elimination of the NASA ACPS. It should be noted that the major thrust of the Boeing-funded effort involves design and manufacturing studies relative to reducing the production costs.

The Boeing Company believes that NASA should continue to focus on basic R&T development to ensure the establishment of the required technical data. Areas of interest include:

Thin skin lightly loaded structure methodology to complement NASA's successful development of high performance thick wing type structure.

Toughened materials and damage tolerance methodology to increase efficiency, reduce weight maintenance costs.

Structural analysis and predictive allowable methodology to reduce test costs.

Service environment response to achieve long service life and reduce maintenance.

Innovative design concepts with attendant testing.

The investment of the $24 million may be maximized by NASA for the ACPS program by focusing on the basic R&T data base requirements and by providing a forum for the exchange of information. The Boeing Company will maximize its expenditures by addressing technical and manufacturing cost issues.

Senator GORTON. Thank you very, very much.

Mr. SCHAUFELE. We at Douglas Aircraft Co. of McDonnell Douglas Corp. are vitally interested in the scope and focus of NASA budgets and I appreciate this opportunity to testify on NASA's aeronautical research and technology budget request for fiscal year 1986.

While industry expend substantial sums on independent research and development, we are strongly dependent on NASA for technology developments and facilities that are beyond the means of any single industrial corporation.

I would like to first reiterate strong support for the rational, forward-looking national aeronautical research and technology policy and the recently announced national aeronautical R&D goals formulated by the Office of Science and Technology Policy in the executive branch.

NASA should be complimented on their role in the aeronautics-2000 initiative that addresses aeronautical needs far into the future in keeping with these policies.

Although the NASA aeronautics budget request for 1986 in general does a fine job of developing the right technology to meet future needs, I would like to address three concerns that I have developed in the assessement of the proposed budget. They are the low level of the aeronautics portion of NASA's budget, the down hill trend projected for the systems technology portion of the NASA aeronautics R&T budget, and the sudden termination of NASA's system technology efforts in composite structures.

As for the level of NASA aeronautics budgets, the scope and complexity of aeronautical technology required for safe, efficient, environmentally compatible commercial aircraft, as well as superior military aircraft, is continually expanding. The ability of NASA to develop technology for timely application by the industry is being constrained by the level of the aeronautics budget.

I recommend that the Congress recognize this national need and begin with a 5-percent increase in the NASA aeronautics budget for 1986.

As for the system technology efforts in the NASA aeronautics programs, NASA has in past years done an outstanding job in evaluating through system studies the benefit potential of technology concepts, to exploit special opportunities, and to accelerate key technology readiness for application.

One of the most successful of these programs is the NASA aircraft energy efficiency program that was initiated in 1975 in response to the subcommittee's specific request. I am dismayed at the NASA budget request for 1986 which shows a reduction in the systems technology effort at a time when the need for this is increasing and the programs involved are vital. It is clearly an area that the increased funding recommended earlier could be applied.

Finally, I would like to address the sudden reduction to zero of the advanced composite structures program. This part of the NASA composite structures plan was the third phase of an effort begun in 1976 in response to this subcommittee's request, and covered critical wing and fuselage composite structure technology. Without that program, technology readiness for such applications will be delayed from 3 to 5 years. And I strongly recommend restoration of as much funding as possible for the planned 1986 effort on this program in keeping with the emphasis on critical systems technology and the recommended 5 percent budget increase.

[The statement follows:]

STATEMENT OF ROGER D. SCHAUFELE, VICE PRESIDENT, ENGINEERING, DOUGLAS AIRCRAFT CO.

Mr. Chairman and members of the Subcommittee, I am Roger D. Schaufele, Vice President of Engineering at Douglas Aircraft Company, a component of the McDonnell Douglas Corporation. Over the past six decades, the Douglas Company has built more than 43,000 military and civilian aircraft and we now produce MD-81/82/83 and DC-10 commercial transports as well as KC-10 tankers for the Air Force (Figure 1). We are also developing for production the MD-87 commercial transport, the C-17 Multipurpose Airlifter for the Air Force, and T-45 Training System for the Navy. These aircraft embody the latest in aeronautical technology and we are defining, for possible future development and production, additional advanced-technology commercial and military aircraft.

While we expend substantial sums on independent research and development, we are strongly dependent on NASA for technology developments and facilities that are beyond the means of any single industrial corporation. Thus, we are vitally interested in the scope and focus of NASA budgets, and I appreciate greatly this opportunity to testify on NASA's Aeronautical Research and Technology (R&T) Budget request for Fiscal Year 1986.

I would like first to reiterate Douglas' strong support for the rational, forward looking National Aeronautical Research and Technology Policy formulated in 1982 by the Office of Science and Technology Policy and agencies of the Executive Branch, including NASA. We agree with its stated goals of "timely provision of proven technology" toward future developments of superior U.S. aircraft and toward a safe, efficient, and environmentally compatible air transportation system. We would, therefore, like to compliment NASA on definition of the "Aeronautics-2000" plan that addresses aeronautical needs far into the future in keeping with the National Aeronautical Policy. We would also like to record our generally positive endorsement of NASA's proposed Aeronautical R&T Budget for Fiscal Year 1986 and our general agreement with the content of the R&T Base portion of it.

In the remainder of this statement I would like to address three concerns I have developed in assessment of NASA's budget as a member of the Air Transportation Subcommittee of NASA's Aeronautics Advisory Committee and, most recently, as a member of the Congressional Advisory Committee on Aeronautics (CACA). They are the low level of the Aeronautics portion of NASA's budget, the steep downhill trend of projected levels of the Systems Technology portion of NASA Aeronautics R&T Budgets, and the sudden termination of NASA's Systems Technology efforts in composite structures. These concerns lead to recommendations for the Fiscal Year 1986 and future budgets.

ON THE LEVEL OF NASA AERONAUTICS BUDGETS

Over the past four decades of rapidly expanding population, air transport has become the dominant public transportation mode by a wide margin and we have become critically dependent on it. As transports have grown in size and performance to meet this demand, they have had to become vastly more complex to achieve increasingly stringent required levels of safety, efficiency, and environmental compatibility. This has fueled a correspondingly vast expansion of aeronautical technology horizons. A similar dramatic expansion of the scope and complexity of aeronautical technologies required for adequate military defense of the United States has also occurred in the same period. In spite of the resulting much greater need for rapid development and timely application of Aeronautical R&T, Figure 2 shows that the level of NASA Civil Service manpower now assigned to aeronautics is the same as the level of NACA manpower four decades ago at the conclusion of World War II.

With the advent of NASA, aeronautics Civil Service manpower was augmented by Aeronautics R&T funds and these have been the source of great benefit to the aircraft industry and the nation in ways I will touch on later in these remarks. But, accounting for inflation, the requested level of the NASA Aeronautics R&T Budget for Fiscal Year 1986 is the same as the level reached by that budget in 1970. Moreover (Figure 3), some 40% of this budget must now be applied to indirect expenses not adequately covered by NASA Research and Program Management (R&PM) Budgets and to the support service contracts required to achieve staffing levels equal to NACA's staff in the 1950's (Figure 2).

Finally, the total resources requested for aeronautics in Fiscal Year 1986 amount to only 8% of the requested NASA budget. I do not challenge NASA's need for greater resources to meet its differing and broader responsibilities in space; but in relation to the nation's need for aeronautics technology, there is clearly not enough "Aeronautics" in NASA!

I also understand, of course, the great current need to achieve net reductions in the Federal Budget. Moreover, I agree that NASA's new initiatives in space are overdue and must be adequately funded. Therefore, the needed substantial increases in NASA manpower and Aeronautics R&PM and R&T funds cannot be fully achieved in Fiscal Year 1986. I do recommend, however, that the Congress explicitly recognize this National need; begin its implementation with a 5% increase in NASA Aeronautics R&PM and R&D Budgets and manpower authorizations over the requested Fiscal Year 1986 levels; and direct the accomplishment of an independent review by existing NASA advisory groups of the nation's needs for Aeronautics Technology leading to recommendations to NASA, OMB, and the Congress on the scope and timing of further inceases to bring NASA's Aeronautics budgets and manpower to levels consistent with these needs.

ON SYSTEMS TECHNOLOGY IN NASA AERONAUTICS R&T BUDGETS

Systems Technology Programs in the NASA Aeronautics R&T Budget are used to evaluate through system studies the benefit potential of technology concepts, to exploit special opportunities, and to accelerate key technologies' readiness for application. They accomplish the last goal largely by funding experimental applications to prove readiness where the cost and/or risk are too high for industry alone and national benefit is expected. Examples are the "REFAN" Program of the early 1970's and the Aircraft Energy Efficiency (ACEE) Programs initiated in 1975 (Figure 4) in response to this Subcommittee's specific request.

The success of these programs in achieving technology readiness and national benefit is well known. The "REFAN" program led directly to the quieter, more fuel efficient engines on the MD-80 and later aircraft, and made feasible the imposition of tighter noise standards around the nation's airports.

To this Subcommittee's credit for foresight, the ACEE Programs have already delivered a multitude of benefits and more are coming. Among these programs were three also focused on engine technology. The Engine Component Improvement (ECI) Program proved the workability and benefit potential of a large number of advanced components applied to improve the fuel efficiency of existing transport engine designs; these improvements have been made and the benefits are being realized daily in reduced airline fuel costs. The Energy Efficient Engine (EEE) Program proved the viability of fuel savings engine design changes and these have since been or are being incorporated into derivative and new engines for still larger gains. Finally, the Advanced Turboprop (ATP) Program verified the potential of advanced propeller designs for operation at jet transport speeds and has already induced advanced design and flight demonstration efforts by the commercial transport airframe and engine industries to define and verify the technology readiness of transports (Figure 5) with new aft-fuselage-mounted, counterrotating-propfan engines that promise up to 20% additional fuel savings (roughly one-half million dollars per year savings per aircraft as today's fuel prices).

The remaining three ACEE Programs (Figure 4) were focused on air-frame technology toward fuel savings. The Energy Efficient Transport (EET) Program enabled us, at the Douglas Aircraft Company, to prove the potential of very advanced supercritical airfoils and of wing-tip winglets for substantial fuel savings benefits; both these technologies are incorporated in the design of the Air Force's C-17 Multipurpose Airlifter now under development (Figure 1). The Composite Primary Aircraft Structures (CPAS) Program enabled Douglas to develop, certificate, and verify the flight serviceability of a rudder for the DC-10 (Figure 6) and has resulted in extensive applications to secondary structure on Douglas commercial transports (Figure 7) and on the Air Force's C-17 Multipurpose Airlifter (Figure 8). The commitment to composite winglet structure on the C-17 has resulted from the CPAS Program development of a Composite Vertical Stabilizer for the DC/KC-10 which will be flight tested on a KC-10 in June of this year (Figure 9). Finally, the Laminar Flow Control (LFC) Program is still underway with flight evaluation of elements of two proposed systems on a NASA Jetstar (Figure 10); the Douglas system, with an electron beam perforated surface (inset), is performing well indeed in these and other tests. Contingent on results of large scale flight demonstration in a very important planned NASA initiative for Fiscal Year 1987, LFC promises fuel saving benefits of up to 20% in long-range aircraft, depending on the extent of application (roughly one million dollars per year savings per large aircraft at today's fuel prices).

Such NASA funding to accelerate the application of technologies has been essential help in our efforts to meet the competition from Airbus Industries, which is fielding new high-technology aircraft with much greater and more direct aid from European governments. Therefore, Mr. Chairman and members of the Subcommittee, you will understand why I was dismayed to see the NASA budget projection in Figure 11. It would cut Systems Technology to less than half its current level by Fiscal Year 1990 to achieve a highly appropriate increase in R&T Base funding. I endorse this increase because the R&T Base programs supported by NASA's Aeronautics R&PM and R&T Budgets provide the foundation from which important technology advances can flow. They also sustain the excellence of NASA's institutional capabilities which are essential to United States industry. But the System Technology Programs are also vital. What is the answer?

While adoption of my earlier recommendations for a deliberately paced increase in the total NASA Aeronautics budget should resolve this problem, Figure 11 implies that Systems Technology efforts to assure and accelerate the transition of technology to application for public benefit are insufficiently valued. Therefore, I would add to my earlier recommendation for establishment of a plan for step-by-step increase of the NASA Aeronautics Budgets, that the Congress stipulate the end goal include a roughly 50-50 split of Aeronautics R&T funds between R&T Base and Systems Technology Programs. This is approximately the split which occurred during the productive years of the NASA ACEE Programs (Figure 4).

ON FISCAL YEAR 1986 SYSTEMS TECHNOLOGY PROGRAMS

Referring to Figure 11, there are three Systems Technology Programs on which I have sufficient knowledge to comment and which stand out because of the proposed Fiscal Year 1986 levels of their funding. The largest proposed Fiscal Year 1986 expenditure is $42M for the Advanced Turboprop Systems Program which will demonstrate in flight a wing-mounted, single-rotation advanced turboprop configuration. However, as noted above, this NASA program has been overtaken by industry plans to flight demonstrate aft-fuselage-mounted, counter-rotating systems (Figure 5). The NASA test configuration remains of interest for future military transport and, as an alternative if aft-fuselage-mounted systems prove unworkable, but its urgency and worth have been severely degraded by the events of the past year.

The second largest proposed Fiscal Year 1986 expenditure is $28.2M for the Numerical Aerodynamic Simulation (NAS) Program which has been described by NASA to the Congressional Advisory Committee on Aeronautics as a continuing Systems Technology Program without a visible end date. This implies an absense of time criticality and, perhaps, some flexibility in the required level of effort. Although we strongly supported this NASA program, it was the Congressional Advisory Committee's opinion—and mine—that the level-of-effort proposed for this program is excessive.

The most noteworthy feature of the proposed Fiscal Year 1986 Systems Technology funding is the sudden reduction to zero of the Advanced Composite Structures

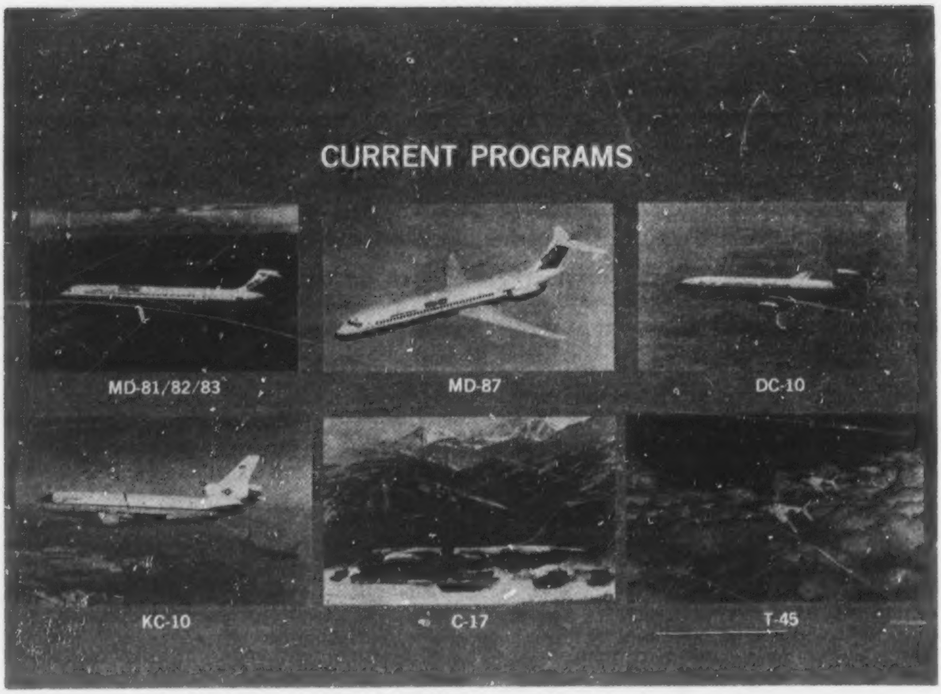
Technology Program. This program, which was higher rated by the Congressional Advisory Committee on Aeronautics than the NAS Program, is the third phase of the ACEE Composite Structures effort begun in 1976 in response to this Subcommittee's request. It was always part of the NASA ACEE Composite Structure Plan to proceed to wing and fuselage structures since major weight and fuel saving benefits can only be realized by such applications. The zeroing of this program in Fiscal Year 1986 constitutes a sudden reversal of NASA's plan one year into this 90 million dollar, 5-year, third phase effort intended to complete the readiness of the transport aircraft industry to apply composites to large wing structure and to achieve partial readiness for fuselage applications. Without this NASA program, the industry's readiness for such applications will be delayed some 3–5 years.

In addition to the genuine possibility that subsidized foreign competition will be now reach this readiness state first, this sudden cancellation will probably also be wasteful in that benefits of substantial NASA investments so far will be compromised. Investments by the industry over the past two years which were aimed at preparing for the expected NASA wing/fuselage effort and for parallel industry-funded tooling and manufacturing efforts committed in "Memoranda of Understanding" with NASA, will probably also be partially wasted. The extent of such losses will depend on future actions not yet defined.

I strongly recommend restoration of as much as possible of the initially planned $25.7M Fiscal Year 1986 funding for this program. Thus, along with the 5% increase by Congress of the NASA Fiscal Year 1986 Aeronautics R&T Budget that I have already recommended, should go the stipulation that the increase be applied toward restoration of the Advanced Composite Structures Technology Program.

SUMMARY

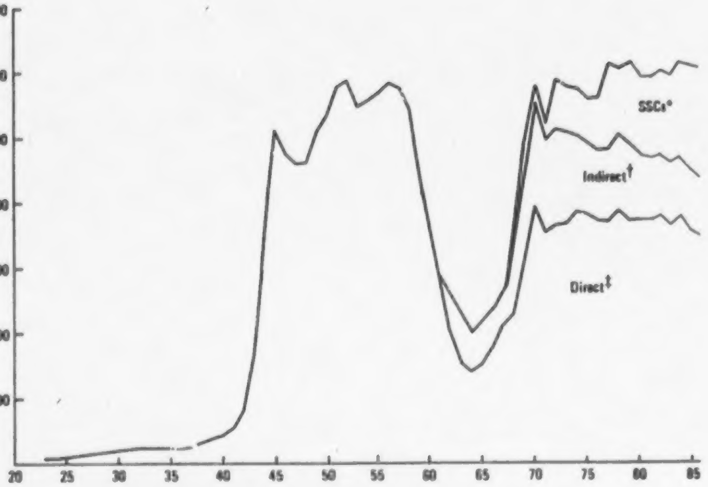
In summary, we in the transport aircraft industry are dependent on NASA Aeronautics technology developments and facilities, not only for the R&T Base foundations of future applied technologies, but increasingly for Systems Technology efforts that accelerate our readiness to apply key technologies and meet stiff government-subsidized competition from abroad. At Douglas, we are alarmed that the continued too-low level of NASA Aeronautics budgets has triggered recommendations to drastically reduce System Technology efforts in future years, starting with the sudden cancellation of the Advanced Composite Structures Technology Program to accelerate industry's readiness to apply composites to the large wing and fuselage structures of subsonic transports. Therefore, we strongly recommend that the Congress: (1) explicitly recognize the need for a major increase of NASA's Aeronautics efforts; (2) direct the development of a plan for the step-by-step accomplishment of the needed total increases in NASA's Aeronautics R&PM and R&T Budgets and Aeronautics manpower authorizations, with the stipulation that an equal division of Aeronautics R&T between R&T Base and Systems Technology by targeted; and (3) begin the implementation of this urgently needed growth with a 5% increase of NASA's Aeronautics budgets and manpower authorizations in Fiscal Year 1986, with the stipulation that this increase be applied to continue Composites Systems Technology efforts.



CURRENT PROGRAMS

MD-81/82/83
MD-87
DC-10
KC-10
C-17
T-45

FIGURE 1. CURRENT DOUGLAS AIRCRAFT COMPANY PROGRAMS



*Support service contractors: contracted in-house technical personnel in direct support of aeronautical programs

†Indirect: professional and non-professional general and administrative support personnel

‡Direct: program scientists, engineers, and technicians in support of aeronautical programs

Source: NASA

FIGURE 2. NACA/NASA AERONAUTICS MANPOWER: 1920-1986

FY 1986 AERONAUTICS R&D BUDGET

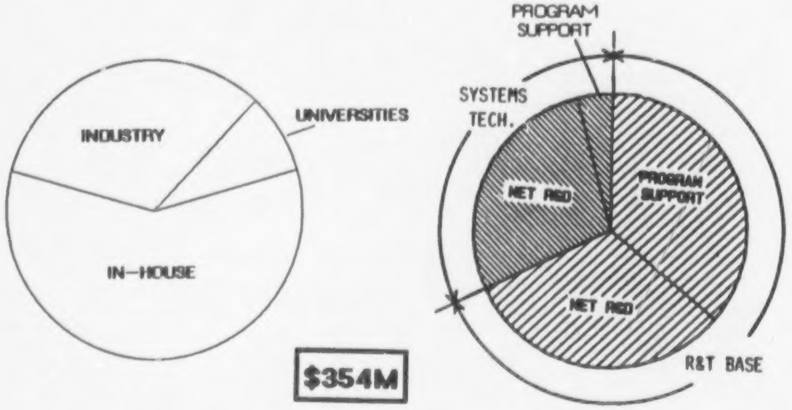


FIGURE 3. INTENDED APPLICATIONS OF NASA FY-1986 AERONAUTICS R&T BUDGET

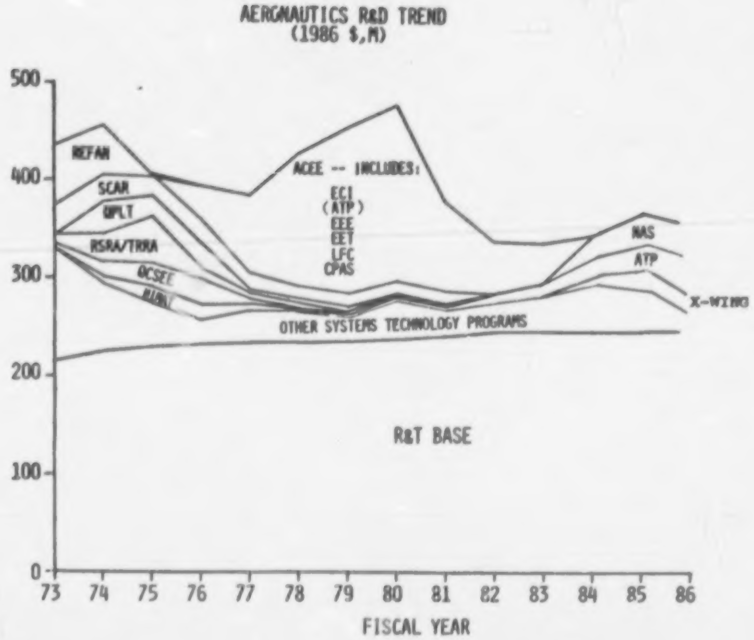


FIGURE 4. RECENT NASA AERONAUTICS SYSTEMS TECHNOLOGY AND R&T BASE FUNDING

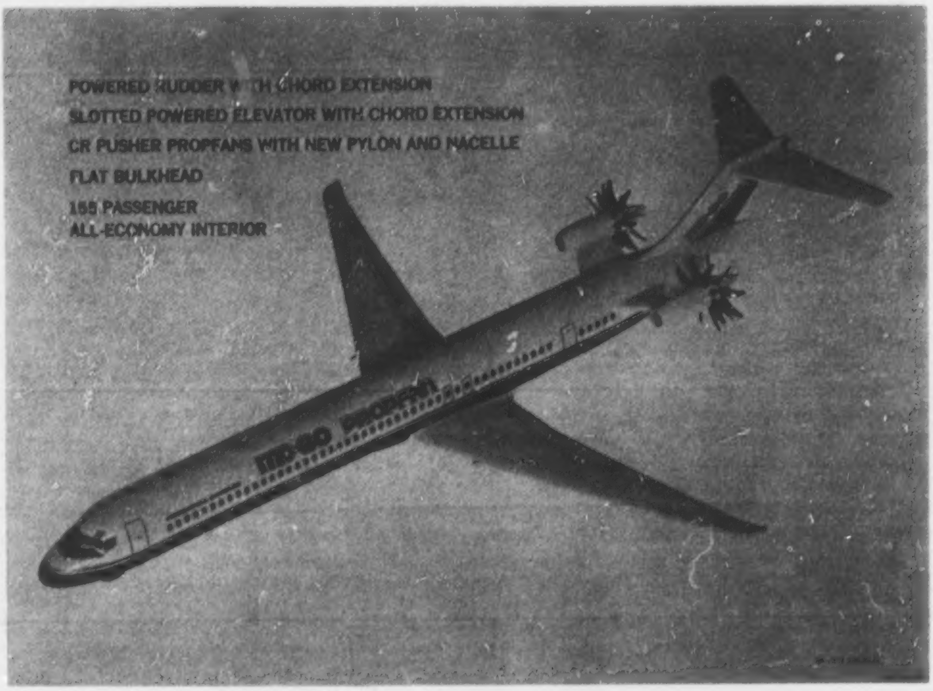
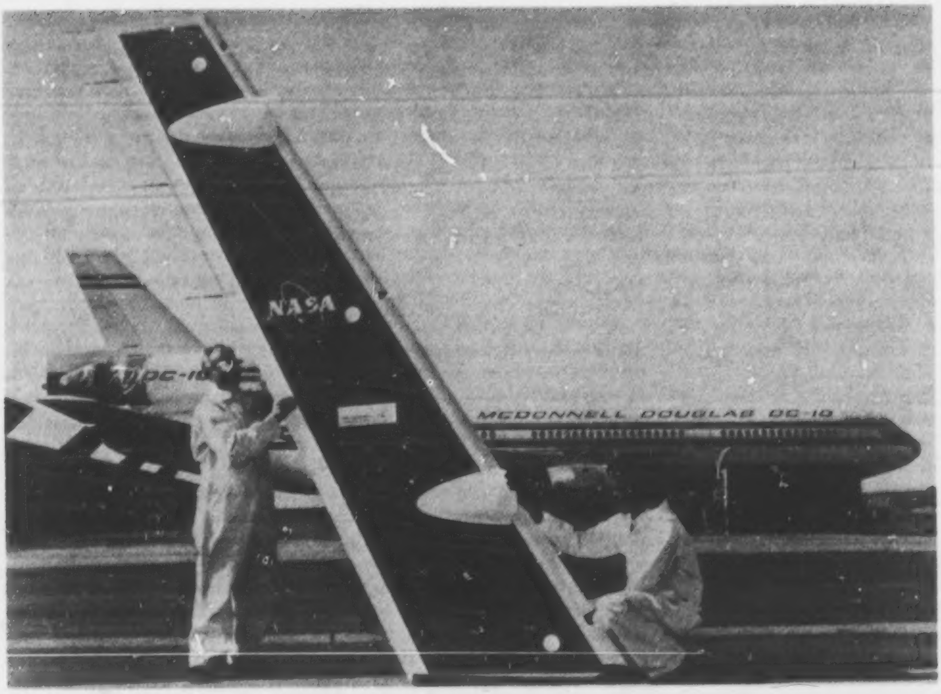
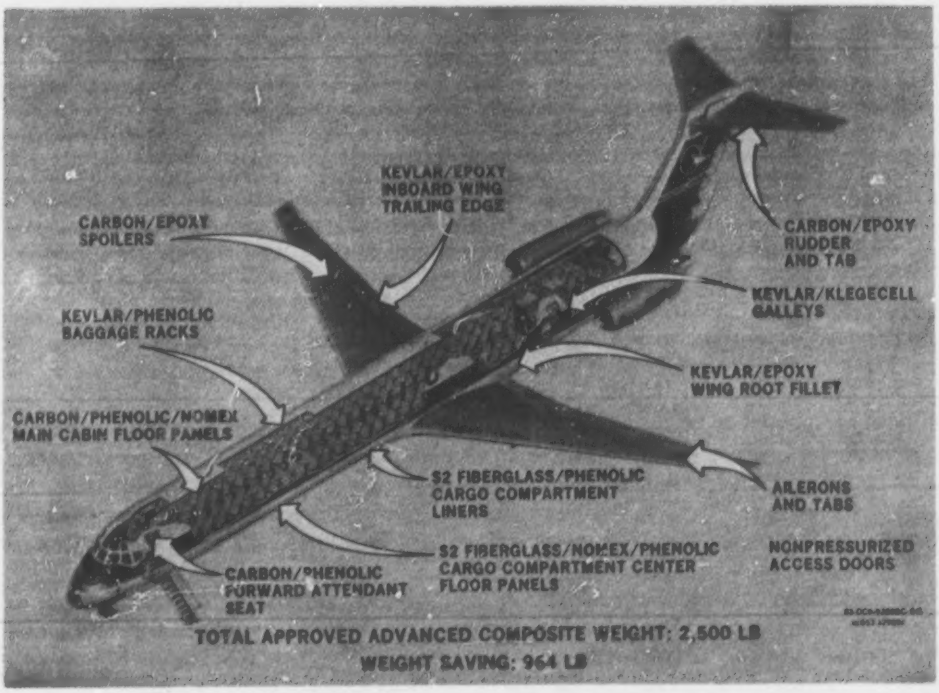

POWERED RUDDER WITH CHORD EXTENSION
SLOTTED POWERED ELEVATOR WITH CHORD EXTENSION
CR PUSHER PROPFANS WITH NEW PYLON AND NACELLE
FLAT BULKHEAD
165 PASSENGER
ALL-ECONOMY INTERIOR
MD-80 PROPFAN

FIGURE 5. ADVANCED PROPFAN DERIVATIVE OF THE MD-80



NASA
McDONNELL DOUGLAS DC-10
DC-10

FIGURE 6. NASA/DOUGLAS DC-10 COMPOSITE UPPER AFT RUDDER



KEVLAR/EPOXY INBOARD WING TRAILING EDGE
CARBON/EPOXY SPOILERS
CARBON/EPOXY RUDDER AND TAB
KEVLAR/KLEGECELL GALLEYS
KEVLAR/PHENOLIC BAGGAGE RACKS
KEVLAR/EPOXY WING ROOT FILLET
CARBON/PHENOLIC/NOMEX MAIN CABIN FLOOR PANELS
S2 FIBERGLASS/PHENOLIC CARGO COMPARTMENT LINERS
AILERONS AND TABS
S2 FIBERGLASS/NOMEX/PHENOLIC CARGO COMPARTMENT CENTER FLOOR PANELS
NONPRESSURIZED ACCESS DOORS
CARBON/PHENOLIC FORWARD ATTENDANT SEAT
TOTAL APPROVED ADVANCED COMPOSITE WEIGHT: 2,500 LB
WEIGHT SAVING: 964 LB

FIGURE 7. COMPOSITE SECONDARY STRUCTURES ON MD-80 TRANSPORTS

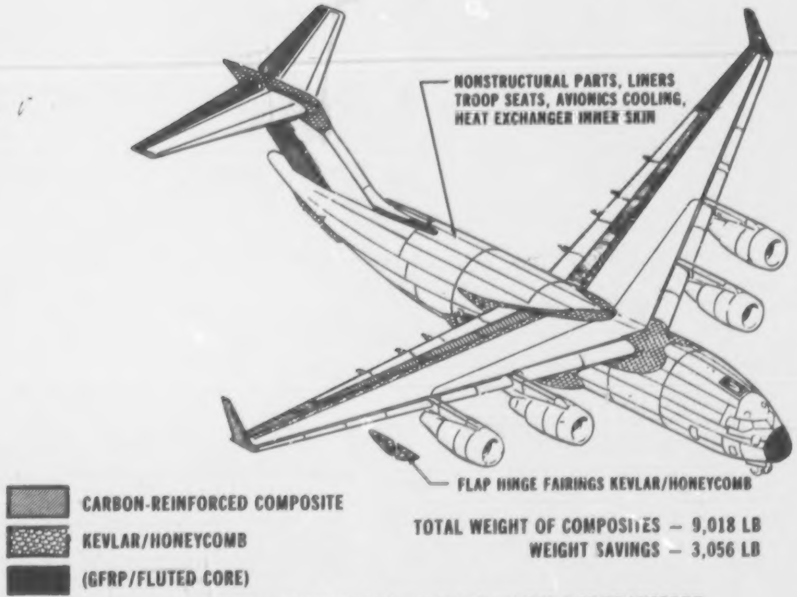

NONSTRUCTURAL PARTS, LINERS
TROOP SEATS, AVIONICS COOLING,
HEAT EXCHANGER INNER SKIN
FLAP HINGE FAIRINGS KEVLAR/HONEYCOMB
▨ CARBON-REINFORCED COMPOSITE
▨ KEVLAR/HONEYCOMB
■ (GFRP/FLUTED CORE)
TOTAL WEIGHT OF COMPOSITES – 9,018 LB
WEIGHT SAVINGS – 3,056 LB
82-C17-4640E

FIGURE 8. COMPOSITE STRUCTURE ON THE C-17 TRANSPORT

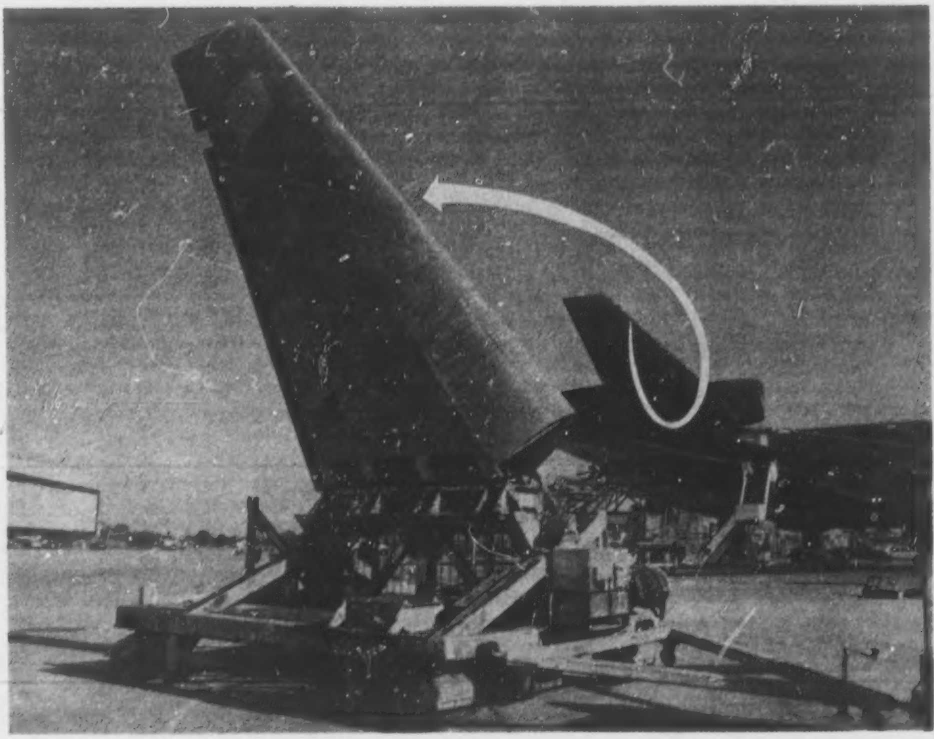
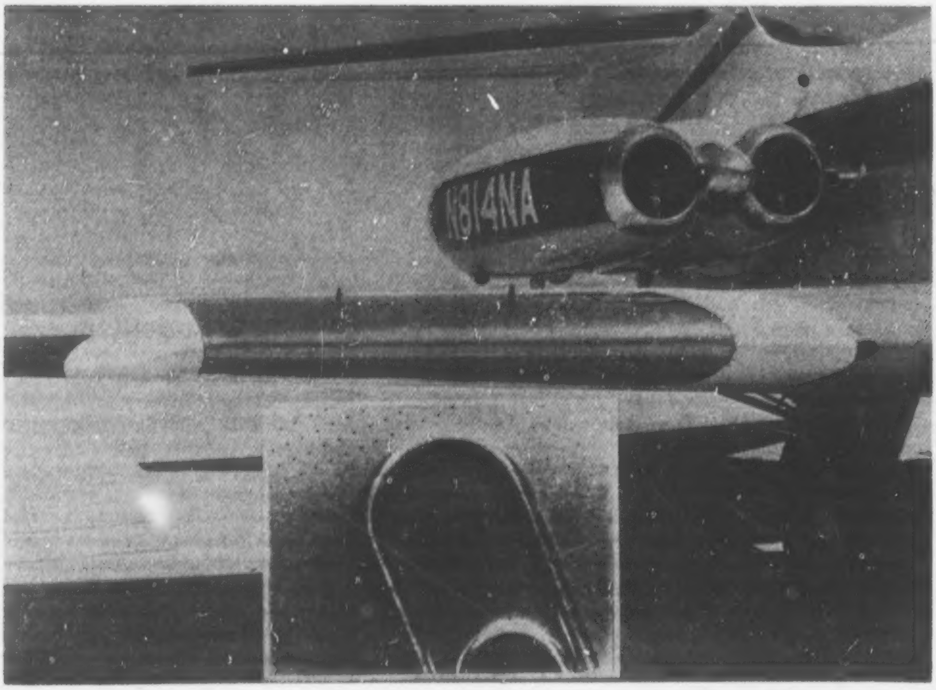


FIGURE 9. NASA/DOUGLAS DC/KC-10 COMPOSITE VERTICAL STABILIZER FLIGHT TEST



'FIGURE 10. DOUGLAS LFC SYSTEM INSTALLED ON NASA JETSTAR FOR FLIGHT TEST

FY 1986 CONGRESSIONAL BUDGET
(Real Year $,M)

	FY 85	FY 86	FY 87	FY 88	FY 89	FY 90
AERONAUTICS RESEARCH & TECHNOLOGY	342.4	354.0	366.5	355.6	349.4	356.7
RESEARCH AND TECHNOLOGY BASE	223.3	23[illegible].3	260.5	275.6	287.6	298.0
FLUID & THERMAL PHYSICS R&T	44.0	48.5	52.8	55.9	58.3	60.4
APPLIED AERODYNAMICS R&T	42.0	43.7	47.6	50.4	52.6	54.5
MATERIALS & STRUCTURES R&T	27.8	28.0	30.5	32.3	33.7	34.9
PROPULSION & POWER R&T	28.7	31.0	33.7	35.6	37.2	38.5
INFORMATION SCIENCES R&T	21.1	22.5	24.5	25.9	27.0	28.0
CONTROLS & GUIDANCE R&T	20.5	22.1	24.1	25.5	26.6	27.6
HUMAN FACTORS R&T	20.3	22.0	23.9	25.3	26.4	27.4
FLIGHT SYSTEMS R&T	16.3	18.3	19.9	21.0	21.9	22.7
SYSTEMS ANALYSIS	2.6	3.2	3.5	3.7	3.9	4.0
SYSTEMS TECHNOLOGY PROGRAMS	119.1	114.7	106.0	80.0	61.8	58.7
ROTORCRAFT SYSTEMS TECHNOLOGY	26.0	20.5	4.6	-	-	-
GUIDANCE & NAVIGATION	-	-	-	-	-	-
RSRA FLIGHT RESEARCH/ROTORS	-	-	-	-	-	-
ADVANCED ROTORCRAFT TECHNOLOGY	9.7	2.7	2.0	-	-	-
TECH. FOR NEXT GENERATION ROTORCRAFT	16.3	17.8	2.6	-	-	-
HIGH-PERFORMANCE AIRCRAFT SYSTEMS TECH.	21.5	21.8	26.0	20.8	16.8	12.1
HIGH-PERFORMANCE FLIGHT RESEARCH	9.7	9.8	10.4	11.0	11.7	12.1
TURBINE ENGINE HOT SECTION TECH.	9.3	5.2	5.0	3.8	3.5	-
CERAMICS FOR TURBINE ENGINES	2.5	2.1	2.2	2.4	-	-
OBLIQUE WING TECHNOLOGY	-	4.7	8.4	3.6	1.6	-
SUBSONIC AIRCRAFT SYSTEMS TECH.	19.0	-	-	-	-	-
ADVANCED COMPOSITE STRUCTURES TECH.	19.0	-	-	-	-	-
ADVANCED PROPULSION SYSTEMS TECH.	26.1	44.2	45.4	32.5	16.7	17.3
ADVANCED TURBOPROP SYSTEMS	24.0	42.0	43.0	30.0	14.0	14.5
GENERAL AVIATION/COMMUTER ENG. TECH.	2.1	2.2	2.4	2.5	2.7	2.8
NUMERICAL AERODYNAMIC SIMULATION	26.5	28.2	30.0	26.7	28.3	29.3
NUMERICAL AERODYNAMIC SIMULATION	26.5	28.2	30.0	26.7	28.3	29.3

FIGURE 11. NASA 5-YEAR BUDGET PROJECTION

QUESTION OF SENATOR GORTON AND THE ANSWERS

Question. Mr. Schaufele, you have stated that NASA's Advanced Turboprop program has been overtaken by industry plans to flight demonstrate a counter-rotation system, and that the urgency and worth of NASA's single-rotation system have been severely degraded by events over the past year. Why is this program less worthy than a year ago?

Answer. Over the past year two industry sponsored flight demonstration programs have been established, both with configurations that are considerably different than the NASA "PTA" program. Counterrotation aft fuselage mounted pusher configurations have been determined most efficient and pracitical by the industry, and most acceptable to numerous airlines worldwide. The NASA PTA program (part of the Advanced Turboprop Program—ATP) is to technically evaluate a single-rotation tractor (puller) configuration which is wing mounted. It is considered to have low potential for commercial application. The majority of the proof-of-concept and demonstration of high loads on the propfan blades can be accomplished in an isolated nacelle (QEC) test in the 40 × 80 foot low speed NASA Ames Wind Tunnel and a QEC test in the high speed Modane wind tunnel. With these tests and the planned industry flight tests, the flight option of PTA could be cancelled and the overall scope of the wind tunnel tests rescoped.

Question. Mr. Schaufele, according to your testimony, NASA's level of effort for its Numerical Aerodynamic Simulation (NAS) program is excessive. The FY-1986 request for NAS is $28 million and the FY-1987 projection provides $30 million. What would be a more appropriate funding level for the NAS program for FY-1986 and FY-1987?

Answer. As noted in my submitted testimony, the program as described to the Congressional Advisory Committee on Aeronautics, of which I was a member, is a computational capability buildup without a specific target or end date for completion. This program provides for increased capability and has no technology as an end product. In my opinion there is no time-critical milestones that are identified or specific application that will see benefits in the near-future term. Therefore in periods of tight budgeting it seems much more efficient to stretch out a program of this nature and fund critical technology efforts that have identified specific accomplishment goals that are of significant performance improvement that industry can accept and make design applications. Long term efforts generally do not have the high front loadings such as exhibited by NASA. A sizable portion of the budget has been established for leasing of computer equipment (should be facilities budget) and could be negotiated over a longer time period for the program startup. A more appropriate funding level would be $21 to $22 million for FY-1986 (20% to 25% reduction recommendation).

Question. Mr. Schaufele, according to your testimony, there is a sense of urgency about completing the Advanced Composites Structures program, but there is an "absense of time criticality" in the NAS program.

What makes the Advanced Composites Structures program so much more time critical than the NAS program?

Answer. Target for the wing portion of the Advanced Composites Structures program was to have technical readiness established in 1988 with final demonstration testing in 1989. With these dates, Dougles had established a goal of including a composite wing primary structure on the production version of the 100-passenger advanced turboprop transport therefore taking advantage of two NASA supported technology developments on our model design. Production design effort would be initiated as part of an advanced turboprop program offer to commercial airlines. Initial drawing release would occur at time of the wing box static/fatigue testing allowing for drawing changes due to testing, if necessary, before an actual hardware development.

Question. Mr. Schaufele, according to your testimony, NASA's budget projections reflect a Systems Technology funding level in 1990 that is about one-half the present level.

What types of Systems Technology programs are conspicuously absent from NASA's budget projections?

Answer. The first and foremost programs that is missing is the Composite Primary Structures program which was submitted in the original budget plan to OMB at $25.7 mil. A second program should be the Laminar Flow Control program. Preliminary planning at NASA indicates that there may be a program advocacy for the FY-1987 budget, but obviously there are no assurances that will happen.

Question. Have NASA's Advisory Committee on aeronautics recommend these programs?

The Advisory Committee had selected the Composites program as number 1 and endorsed the Laminar Flow Control program. The House Congressional Advisory Committee on Aeronautics (CACA) also endorsed the Composites program and recommended funding be reinstated.

If so, why has NASA not included them in its budget projection?

Answer. It is assumed that the budget levels established by OMB have forced NASA to make cuts and obviously the R&T Base is last to be reduced because the majority of these programs represent inhouse NASA research. The major technical integration programs in Systems Technology are mostly contracted effort and are less painful to curtail since it would minimize internal disruption of NASA personnel.

Question. On Monday, the White House Science Advisor released a report on national aeronautical R&D goals, one of which is related to subsonic transport.

One of the technologies mentioned in this report which would support subsonic aeronautics is all-composite primary structures. Yet the Administration terminated NASA's Advanced Composite Structures Technology program.

Can industry develop the relevant composite technologies in support of this subsonic transport goal?

Answer. Industry can eventually develop the composite primary structures technology, but within the resources available it will take a longer time without NASA funding. Without inhouse priority changes and infusion of additional funding, the program impact due to curtailment of the NASA composites program delays the technologies readiness 3 to 5 years. Obviously Douglas will re-evaluate its overall advanced technology program in light of NASA's actions to try and recover some of the anticipated delay. The possibility of a higher risk for the application can also be considered. If the target were a military transport the DoD would absorb the risk as it does on all its programs. For a commercial program the risk has to be considerably less because the total investment is not required until several hundred units are delivered, and you cannot afford any mistakes or you lose your company.

Question. Can industry accomplish the same technology objectives as the NASA program related to primary composite structures, only at a slower pace?

Answer. Yes as explained in the answer to the previous question.

Question. What is the appropriate role for the government if this technology is to support a national aeronautical goal?

Answer. The government role, in this case NASA, would be to provide major assistance in the technology development and large scale integrated testing for proof-of-concept. The industry role is to develop the low cost manufacturing capability of the concept and invest in the design, development, and testing for certification of the production product. The NASA CPAS program was focusing on the technology and industry was preparing to invest in parallel for the manufacturing development.

Question. How can the $24 million investment to date in NASA's Advanced Composite Structures program be maximized?

Answer. The FY-1985 program was budgeted at $19 million of which the majority was for the initial effort in CPAS wing and fuselage programs. To date NASA plans to reduce the scope of existing contracts below $13 million of the FY-1985 budget with no indications of any continuation of the effort into FY-1986 (currently proposed at zero budget).

Question. The National Research Council report also suggests that it would be in the best interests of NASA and the U.S. aircraft manufacturers to assign a higher priority to the collection and evaluation of foreign technology. Should we be doing more in this area?

Answer. Yes, but not at the expense of the currently underfunded R&T Base and Systems Technology effort.

Question. On the other hand, is our own technology too available to our competitors?

Answer. Yes, the U.S. technology development is very valuable to foreign competitors. At subsidized development from their governments, they can conduct application of the technology without having to validate or demonstrate at their expense. U.S. industry in the commercial/private sector has to have their own capitol or borrow funding to develop the application to a product—usually at the going market interest rate.

Question. The White House report on national aeronautical R&D goals also mentions goals related to supersonic cruise transport, and the White House Science Advisory said that, while the Administration has made no commitment to a supersonic transport, it is laying the ground work, both in NASA and DOD, in the fundamental supporting technologies. Is NASA adequately supporting the technologies that will lay the groundword for a supersonic transport?

Answer. Not as identified in the FY-1985 and FY-1986 budgets for the time table identified in the National Aeronautical R&D Goals document.

Question. If not, what should NASA do differently to support this goal?

Answer. If the vehicle system is identified as a National Goal, the Administration should allow NASA to set up a separate budget category for the program and not bury the effort across a series of R&T Base and Systems Technology line items. The currently authorized FY-1985 budget and proposed FY-1986 budget are inadequate to take care of the growth needed to continue existing programs. The economic justification for a supersonic transport is difficult to justify and therefore would have to be established as a National Goal and the R&T Base/Systems Technology program funded to develop the technology an a separate program goal within NASA to develop and test two demonstrator flight vehicles. When the technology has been acceptably developed, the government under its National Goal program would have to underwrite the loan guarantees to develop the production systems.

Question. The third goal in the White House report on national aeronautical R&D goals concerns transatmospheric transport. How soon is theer likely to be a national requirement for such a capability—will it be largely civil or military?

Answer. From a civil/commercial application the justification for the supersonic transport is marginal. To consider a flight vehicle that will explore M-5 or greater and even be a space vehicle cannot be economically justifyed as a commercial transport system.

Question. How much would it cost to develop this capability and over what period of time?

Answer. Development testing, design, temporary tools, fabrication, and assembly of two scaled versions of the potential system are estimated to be in the $5 to $15 billion level (to the point that certification of a prototype/preproduction system could be technically undertaken with acceptable risks).

Question. Do NASA's present and projected budget requests adequately support these transatmospheric technologies?

Answer. No. The magnitude of budget required for the supersonic and transatmospheric technologies are above the current levels planned.

Question. The White House Science Advisor, when questioned about an increase in NASA's aeronautical budget to support these three national aeronautical R&D goals said that he did not foresee a significant increase.

Can we make significant advances to subsonic, supersonic, and transatmospheric aeronautics as national goals with a NASA aeronautics budget that continues to grow at a rate no greater than inflation?

Answer. No. It is not possible.

Question. What kind of increases in NASA's aeronautical R&D budget are necessary to permit these goals to become a reality?

Answer. The immediate aeronautical budget would have to at least double each year for at least the next four years focusing on two demonstrator/research vehicles and level loaded for at least one year (5th year) upon entering a flight program for two years at half the level loaded effort.

Question. What can industry do to support these goals?

Answer. The major budget growth over the next four years to develop a transatmospheric demonstrator could take up some of the available slack for existing high performance engineering design teams. It would put a strain on available manpower and facilities for testing, but as a national goal it could be done.

Question. With one industry team planning to conduct in 1986 a flight test of its counter-rotation turboprop technology, does this in any way reduce the justification for NASA conducting a flight test of the single-rotation configuration, after the industry-sponsored test?

Answer. I would like to correct the question by indicating that there are two industry teams planning to conduct counter-rotation advanced turboprop flight testing. Douglas has committed to a flight program. The 1986 industry flight test does not relate to the NASA PTA advanced propfan propeller blade. The 1987 planned counter-rotation geared system flight test blade design will take advantage of the development data generated under the PTA program. Just how far a modified ground test program will take the blade design verification is a question that Hamilton Standard should answer. If the high speed wind tunnel test was modified to provide power for an eight bladed test at design disk loading, the industry counter-rotation flight program would have to be expanded to obtain more design buildup test data if the PTA flight program was cancelled. Here again, Hamilton Standard should be responding to this question.

Question. The second national aeronautical R&D goal of the recently-released report by the Office of Science and Technology Policy relates to supersonic transport. Dr. Keyworth said that although the Administration has made no commitment to such an aircraft, it is laying the groundwork at NASA and at the Department of Defense.

How soon would we be able to respond to a call for a supersonic transport aircraft and at what cost to NASA and the DoD? How and to what extent does NASA's budget request support the fundamental technologies related to supersonic aeronautics?

Answer. The FY-1986 budget report does not have sufficient funding in supersonic aeronautics (aerodynamics, structures, and propulsion) to support a national goal.

Question. Concerning the goal of transatmospheric aeronautics, how soon do you envision a national requirement for such a capability and what are the potential requirements for such a capability.

Answer. A justification cannot be made for a civil application that included economics of development and operation. Some radical changes in fuel costs and types with a write-off of the development cost would have to happen as well as a substantial increase in NASA aeronautics R&D funds.

Question. How and to what extent does NASA's budget request support these fundamental technologies?

Answer. There are insufficient funds in the FY-1986 budget to even look at or define what the technical issues are of a total vehicle system.

Question. When asked if the Administration's new goals in aeronautical R&D would require an increase in NASA's aeronautical budget, Dr. Keyworth said that he did not foresee the need for an increase to support these goals. Can we realistically expect to achieve these goals without any significant increase in NASA's aeronautical budget?

Answer. The goals identified in the Administration's aeronautical R&D policy issued 1 April 1985 cannot be obtained with the present NASA aeronautical R&D budget.

Question. How can we accomplish these national objectives within the NASA aeronautical budget that grows only at a rate to keep pace with inflation?

Answer. The national objectives can eventually be satisfied with a NASA budget that grows at a rate to keep pace with inflation, but the timing would be considerably beyond the 1995 target of technical readiness identified in the policy.

Question. According to NASA's budget projections, NASA intends to terminate its Rotocraft Systems Technology programs by FY-1988. What is the justification for this action—will there no longer be an appropriate R&D role for NASA after FY-1987? It appears that the market share or our foreign competition is growing year by year—is this simply a trade issue?

Answer. The current budget projections reflect the winding down of two major research programs that included flight vehicle systems that were cooperative programs with DoD. A new Systems Technology program has not been formulated at this time to be fed into the NASA budget planning cycle. Rotocraft technology is supported by DoD and the development program is continuing in difference to subsonic transport that has little DoD R&D.

Question. Year after year, Congress and presumably NASA is faced with the question of deciding at what point NASA should no longer conduct certain work and industry should assume the responsibility. We all know that this decision is based on assessments of risks, lead-time of payoffs, and facilities, but could you expand on this and share with us just how this decision is made?

Answer. There is no question that the role of NASA to conduct and support R&D Base and generic systems technology research is proper. Large scale proof-of-concept demonstration testing is also proper in order for industry to be able to accept the results and make its own specific application. There have only been a few examples where industry products are affected and in those cases there generally has been recovery of cost clause with the government receiving payback, if the product is sold.

Question. The National Research Council report suggests that it would be in the best interests of NASA and the U.S. aircraft manufacturers to assign a higher priority to the collection and evaluation of foreign technology. To what extent are we presently taking advantage of available data of our competition?

Answer. Competition is assumed to be foreign in this question. Through conferences, symposia, and technical visits, the U.S. industry is able to keep abreast of the state-of-the-art progress of foreign competition.

Question. How can we improve our efforts in this area?

Answer. Through the use of data collection and reporting. Possible expansion of existing document centers to handle the specific categories of foreign technology reporting.

Question. The National Research Council report, to which I referred to in my opening statement, recommends a "re-examination of the research and technology development activity in support of civil aviation in NASA, in light of the changing competitive environment and the technical opportunities noted in this study."

Could you share with us your thoughts on this recommendation?

Answer. The recommendations are proper and logical in light of the status of U.S. industry in comparison to the foreign competition. The strength and health of the airframe industry is tied to the strength of the NASA aeronautics R&D. The reduced level of NASA budget has severely limited NASA facility improvements and adequate support staffing.

Question. To what extent is NASA likely to conduct this "re-examination?"

Answer. In order to conduct the re-examination of NASA facilities and research programs, a serious change in budget forecast will have to take place.

Question. This report also recommends that NASA reconsider its activities relative to the validation of new technological advances for certification and public acceptance. Since technology validation is within NASA's charter and because most industrial firms lack the resources to undertake certain work of this nature, should NASA reconsider its role relative to technology validation?

Answer. Yes, NASA should consider expanding its Systems Technology program to include large scale integrated technology validation using the industry's technical capability in performing this function. Once the concept has been demonstrated to the point of predictive confidence, industry is then in a position to create its own design application and make guarantees to sell the product.

Question. I understand that NASA has $5 million in this budget request for planning related to the development of an Altitude Wind Tunnel at Lewis Research Center, a development that could cost as much as $160 million. What unique capabilities wold this Wind Tunnel provide that do not presently exist in Air Force tunnels or other facilities?

Answer. The proposed modification of the Altitude Wind Tunnel as a large scale icing facility would be the largest icing test section in existence.

Question. To what extent will the size of the test section of this tunnel limit the ability of the tunnel to test large size aircraft/propulsion systems, prop-fans, or helicopter rotors?

Answer. Being that the Altitude Wind Tunnel would be the largest of its kind, it would be able to test full scale some of the largest propulsion systems, some with partial aircraft representation, and propfans up to the largest diameter considered for the next two decades.

Question. What are the projected annual operating costs of the Altitude Wind Tunnel?

Answer. NASA has indicated it would take in the order of $5 million per year to operate the Altitude Wind Tunnel.

Question. Do you believe that the consensus of industry supports an investment of $160 million and annual operating costs of this magnitude for the Altitude Wind Tunnel at Lewis Research Center?

Answer. The Congressional Advisory Committee on Aeronautics (CACA) made a fairly thorough examination of the Altitude Wind Tunnel and its finding was that the return on investment was not advancing the state-of the-art enough to justify the program. In light of tight budget restraints and stacking key programs in priority, the Altitude Wind Tunnel would not be near the top.

Question. On Monday, the White House Science advisor, Dr. George Keyworth, released a report that proposed national aeronautical R&D goals in subsonic, supersonic, and transatmospheric transport.

Dr. Keyworth said that in the area of subsonic transports, all-composite primary structures would be brought to maturity in the 1990's.

Is it possible to develop this composite technology in support of the subsonic transport goal in spite of the Administration's termination of NASA's Advanced Composite Structures Technology program—can industry fulfill this technology objective or should the Administration continue NASA's Composite Structures Program?

Answer. It is not possible to satisfy the Administration Aeronautical R&D Policy in the time period identified if the Composite Structures program is zero funded in FY-1986. NASA should continue to support the program in order to develop the composite structures technology focus at primary wing and fuselage structures.

Question. Is NASA prepared to request funding for the Advanced Composite Structures Technology in FY-1987 in light of the recently released national goals for aeronautical research and development, or does NASA consider this program terminated?

Answer. There are no assurances that NASA plans on funding or generating a new initiative in FY-1987 to reinstate the composite primary structures program. Action has already been taken at NASA Langley to abandon the NASA Project Office for this effort and they have even redistributed the FY-1985 funds and reduced the scope of several existing contracts in favor of other work. NASA's actions indicate the Systems Technology program has been terminated.

Question. How have the assumptions and justifications for the Advanced Composite Structures Technology program changed from two years ago when you initiated this program—what is different now than then?

Answer. There are no changes in the assumptions and justifications for the program. The NASA reasons for cancelling the program are improper and made without full understanding of the technical issues regarding the differences in program funding to date on secondary and small primary versus highly loaded wing primary structures. The material system would allow the design of high aspect ratio wings that would not be performance competitive if made in metallics. The material system was allowing configuration improvements not available through metallics. Further, there is a projected cost reduction in manufacturing of the composites in comparison to the metallic structures. Therefore the program was to validate an advanced technology that could demonstrate benefits in weight reduction, performance improvement due to advanced configuration, and cost savings due to reduced manufacturing costs.

Question. How do you plan to maximize the utility of your $24 million investment to date in this program?

Answer. To date the NASA funding has been less than the $24 million and is scheduled to be further reduced because the project has been dissolved. In-house at Douglas a re-prioritization of major programs will have to take place without the NASA funding for composites. The overall effort could be a general stretch out of several programs in order to provide adequate support for composites. The funding planned by Douglas to develop the tooling for the wing program in parallel with the wing technology development program will now have to be used in the technology development of highly loaded composites as well as causing a program stretch-out.

Senator GORTON. Thank you.

Mr. Hopps.

Mr. HOPPS. Thank you, Mr. Chairman. I welcome this opportunity to speak to you. You have received my written statement so I will just quickly paraphrase from it and add some additional comments. We are all aware of the role that aviation plays in our Nation's economy and security. But, there are some problems.

There is no question that general aviation sales are determinating. Helicopter sales are down and only equal to the Europeans, where only a few years ago they were twice as great, and foreign competition is attacking our commercial transport market.

I believe this hearing is important because never was it more important to assure ourselves that the goals that our Nation has in aeronautics are adequately supported by NASA's research endeavors. Never have we had so many opportunities so close, and yet not quite within our grasp.

We are now in an era in which we have the opportunity for more technological advancement than we have ever had in the past; these are explained in my written testimony. The United States has the opportunity of producing new vehicles of such significance that obsolescence of many current aircraft is potentially possible.

To provide a reasonable possibility that these opportunities will occur, we must be more aggressive in our aeronautical research. However, holding a constant budget, even in constant dollars, is not keeping up with the R&D cost association developing a new aircraft. In constant dollars, it costs many times what it did just 10 or 15 years ago. Industry, by itself, cannot and has not conducted the research base that led the United States to its enviable position in aeronautics.

I understand the severe pressure on the national budget and, therefore, the NASA budget, and it is with much thought that I recommend a substantial increase in NASA's aeronautics budget. To meet our Nation's goals, the budget should be increased by about $100 million a year.

In the big picture that is not a large amount of money when one examines total budgets. We are losing ground in aeronautics; it shows it in the marketplace.

Now, if we cannot increase the budget, there is an alternative. This alternative requires having the courage to place the NASA programs in their proper priority.

I believe that we can maintain the budget while and adding some money to rotorcraft technology, advanced materials, and supersonic research, by having an equal reduction in the areas of computational fluid dynamics, the oblique wing program, and the planning for a new NASA facility.

On the airplane yesterday, I tried to think of how I might provide some additional insight for you. I had time to think about why you are receiving such diverse opinions regarding some of NASA's programs, and I believe I know the answer. Most organizations and study groups—and I have served on National Academy committees and AIAA study groups—are asked questions that are very broad, such as "What is NASA's role in aeronautics?" or "Does a particular aircraft concept have any potential?" et cetera.

Well, in the first question, we examine all the technologies and their benefits and define a very large role—but without a budget constraint. In examining the specific question regarding a unique concept one will usually find an application. Therefore, the answer is yes and a document is written that states there is a potential. Again, not examining budget constraints.

Or individuals or committee are asked, "would a new wind tunnel be used?" And, of course, the answer is yes. Again, there is a document produced that ways it is useful—and, therefore, it should be funded. But, these are the wrong questions in the real world.

The right questions to be asked are, "with limited funds, is it something I should do?" or, to put it another way, "if I do it, what will I give up?" That is the real world. We do not have unlimited funds. And that is why I am addressing the need for priorities. And that is why I am taking the position that I do on some current programs.

I have to comment on some of the statements made regarding computational fluid dynamics. It is an important field but it does not possess the ingenuity and imagination of the human mind and that is what is going to lead us to new vehicles in the 1990's. Until we get artificial intelligence that includes these factors, and I do not know if that will ever come, we must keep balance in the programs. I am a supporter of computational fluid dynamics but we are not spending just $25 or $27 million in this area, as has been stated.

If you examine the congressional report of the committee that both Roger and I served on, you will find that across the various

Centers, the committee totaled something like $60 million that is being expended in this area. All we said is let's move about $5 million of it to do some of the high priority work that can lead us to more ingenious designs that provide the opportunity to once again move ahead in aeronautics. I think our budget problem is a priority problem.

Finally, I would also like to support what Mr. Kirchner of Boeing said regarding the need for variation of parameters in the turboprop program. In the current program, what he described is exactly what is being done. It is not locked into a single rotation propeller or a particular engine. It is developing methodology that understands blade design, stresses, flow fields, and community noise. This methodology will apply to both single rotating, and counter-rotating systems. But it should also be noted that counter-rotating, as far as we know, still has high noise problems which require solution. The methodologies of this program will apply to all configurations.

And the one thing we cannot afford to do is keep turning programs on and off, just as was done recently in the composites technology. We and NASA started and aggressive program—In fact, we put more money in the program than NASA did. When NASA funding was terminated, we didn't complain; we understood the budget problem. But we cannot keep turning programs on and off, it leads to nowhere. We do need a long-range and dedicated plan in these important programs.

With your support I believe we can bring our nation back to some preeminence in aeronautics, but we either need to add money or have the courage to place the proper priorities on the programs.

Thank you.

[The statement follows:]

STATEMENT OF RUSSELL H. HOPPS, VICE PRESIDENT, ENGINEERING, LOCKHEED CORP.

Mr. Chairman, Members of the Subcommittee, Ladies and Gentlemen: My name is Russell Hopps. I am Vice President of Engineering for the Lockheed Corporation. I have been intimately involved in aeronautical research, technology and aircraft development for thirty years. I serve as an advisor to the NASA on aeronautics and I am also a member of the recently formed Congressional Advisory Committee for Aeronautics.

I welcome the opportunity to speak to you on the subject of the NASA aeronautics programs with respect to their ability to fulfill our nation's goals in aeronautics.

Before discussing the details of the NASA programs, it is important to give a brief description of our industry to illustrate its large overall impact on the U.S. economy. Employment in the aeronautics industry, which includes development and production of aircraft, engines, and parts, totals about 600,000, a number exceeded only by the auto manufacturing industry. Some 10,000 companies in all 50 states contribute to this nation's aircraft production. Overall sales in the aircraft sector in 1983 were approximately $38 billion. Export sales of the aeronautics industry, i.e., aircraft, engines and parts amounted to about $15 billion in 1983. Final values for 1984 are not yet available, but it is not expected that they would be significantly different. In recent years aviation products have been the biggest single contributor of any manufacturing industry to this nation's net balance of trade. Our nation's aviation industry has produced military and civil aircraft and equipment that are respected throughout the world.

Aviation is also a prime element of our nation's economy and security. The importance of aeronautics is confirmed by the fact that approximately one-third of the Department of Defense (DOD) Budget is for procurement, maintenance, and operation of aeronautical systems. Our national transportation system depends on continued progress in aviation. There can be no doubt that is possible. Through the results of aggressive aeronautics research the U.S. could have in production, in the

1990s, much more capable tactical aircraft, more efficient rotorcraft, and extremely efficient transport aircraft. Both the civil and military fields of aviation would benefit.

To provide a reasonable possibility that these opportunities will occur we must become more aggressive in our aeronautical research. NASA's budget for aeronautics has not maintained the level required to foster and support new production possibilities as it did in the past. NASA has been, and should continue to be in the future, a prime factor in securing the preeminence of U.S. Aeronautics. However, providing a level budget—even in constant dollars or constant manpower is not sufficient. It does not recognize the fact that R&D costs associated with a new aeronautics endeavor are escalating much more rapidly than would be estimated by any inflation parameter. A program started today as compared to a similar program begun 25 years ago—again, in constant dollars—requires many times the R&D expenditure than that required by the program of the past.

In my opinion, we are not maintaining the type of historical NASA R&T base that led our country and industry to worldwide supremacy in aeronautics. It was an aggressive NASA/government/industry partnership that provided the United States with worldwide dominance in aeronautics. Historically, NASA developed a generic data base of high risk/high payoff technology which industry further expanded upon. NASA's research was a major factor in making the U.S. dominant in aeronautics during the past several decades. NASA provides the seeds and the initial growth of new technology resulting from research—industry then nurtures the NASA research results and applies it in a viable product. Today, the total aeronautics industry in conducting its research has an annual expenditures which is only somewhere between equal to or twice as great as that spent by NASA. Industry cannot, and has not in the past, conducted by itself the research which led the U.S. to its enviable position of preeminence in aeronautics. NASA's role in high risk proof-of-concept validation such as the forward sweep, laminar flow, X-wing, advanced turboprop flight programs, and viscous drag reduction is extremely valuable to the industry. Industry will develop technology sooner and be more competitive with foreign competition with NASA's help. But with funding limitations, NASA's base of data is not as timely as it could be. Timing is just as critical as technology in the marketplace. Reasonable additional funds could solve this problem. We must improve the situation—it can be accomplished.

Others have expressed similar concern.

The National Academy of Engineering, in a report released just last month, "The Competitive Status of the U.S. Civil Aviation Manufacturing Industry," expressed considerable concern about NASA's current budget for aeronautics, and because of the budget questioned its ability to maintain the necessary momentum in R&D. It states:

"The bedrock of U.S. leadership in civil aviation is technology—its development and incorporation into new designs. That leadership need not be threatened provided that the U.S. maintains a vigorous program of research and development. The National Aeronautics & Space Administration (NASA) is the focal point of aeronautical R&D for both civil and military applications. The high cost of R&D and the massive facilities required for aeronautical R&D preclude any private enterprise from performing NASA's central role.

"Technology Validation represents another area of concern."

"Technology validation is expensive, time-consuming, and risky—technology validation work receives limited support from NASA, and adequate funds are not available to do more at present. Thus, a serious gap exists in the total process of developing and applying new technology."

ADDITIONAL FUNDING AND/OR REBALANCING THE CURRENT PROGRAMS

Before discussing the details of the programs and their funding I would like to state that NASA is, in general, doing an excellent job with the resources at its command. It is making significant contributions to aeronautics and every NASA employee can be proud of their contributions.

I do not understand the severe pressures on the national budget and, therefore, the NASA budget. It is, therefore, with much thought that I strongly recommend additional funding for aeronautics research. One might expect me, because of my background, to recommend additional funding in aeronautics research—but I do it because I believe that it is urgently needed in order to attain our nation's goals and that without it our nation will continue to lose its position of dominance in aeronautics. If our goals were considerable less than stated, the budget would be sufficient.

An additional 100 million dollars in the Aeronautics budget would result in substantial added research which would fill most of the needs in the aeronautics community. Such a sustained increase, during the coming decade, could reestablish and solidify a preeminent position for the U.S. in aviation.

However, if it is not possible to increase the overall NASA aeronautics budget, I suggest that some small redistribution of the currently available money should occur. The funding change would focus on the support of important underfunded areas and at the same time provide a better overall balance to the NASA research. By balance, I mean weighing the factors of the importance of the research output, its timing with respect to the marketplace, the difficulty or effort required to obtain useable results, the size of the marketplace, and the importance of the results to the military.

Therefore, if the aeronautics budget cannot be increased, I believe the following changes should occur in NASA's 1986 planning.

ROTORCRAFT

Rotorcraft funding should be increased. It is a significant market sector in which our traditional superiority is being severely threatened. Only a few years ago the U.S. was producing twice as many helicopters as the Europeans but today their deliveries are about equal.

NASA has tried to absorb its share of the X-wing program within the general rotorcraft funding level. In the past such major flight experiments have received additional funding. Rotorcraft technology, excluding X-wing, was reduced dramatically this year. NASA's R&T base does provide some support to the helicopter field but it falls far short of that required. There are still extremely complex basic technology problems whose solution can greatly increase the efficiency and competitiveness of U.S. products.

A minimum of about five million dollars should be added to rotorcraft systems technology work in structures and materials with particular attention to vibration. Advanced methods for structural dynamic analysis to control and reduce vibration are needed. Noise and vibration are areas that with additional research the U.S. can attain a competitive edge.

COMPUTATIONAL FLUID DYNAMICS

Computational fluid dynamics can be reduced slightly in funding. It is an important design tool to solve aerodynamic problems and it will become increasingly effective in providing advancements in aeronautics. But it is an analytical tool. It is not a substitute for the imagination and ingenuity of the human mind working in harmony with theory and an experimental data base. Artificial intelligence that includes the factors of imagination and ingenuity are decades away—certainly not available to assist our marketplace needs for the year 2000. For the foreseeable future, computational aerodynamics and the National Aerodynamic Simulator will not eliminate the need for experimental research on complex and innovative configurations. Therefore, NASA, with its limited resources, is probably dedicating too much of its resources to this activity. Funding, including direct and indirect, appears slightly out of balance when examining other high priority R&D activities, such as experimental aerodynamics, advanced structures, and many other innovative R&T needed which will directly improve our next generation aircraft. Computational aerodynamics is important but its large potential effect will be felt much further downstream. We must remember that we need strong research output during this decade if we are to affect the 1990's. Some limited rescheduling of funds is justified.

OBLIQUE WING

The funding for the Oblique Wing program could be reduced without affecting the output which is required by the industry. The program should be continued with some additional wind tunnel tests and meaningful system studies since the concept does have the potential for application in a special military vehicle. However, the full-scale flight test program does not appear to be warranted. There are no known scaling problems which justify the large expense associated with the flight vehicles, its systems, and its test. Almost all of the work associated with design, automatic flight controls, and stall characteristics would have to be redone if such a military vehicle were proposed. This was also the position taken by the Congressional Advisory Committee.

ADVANCED COMPOSITES

Recent budget reductions in this area will result in some setback in composite programs for large primary structure. It is unfortunate that the more aggressive program could not have been continued. (But again, I understand the pressure on the budget.) On the order of an additional $20 million is required to reinstate the original program. However, industry is currently working with NASA to redefine a program with reduced funding which will still provide an increase in the nation's generic data base in this most important area. The proposed studies address the problem to reducing manufacturing cost of composite structures through improved materials and innovative designs; they also include the understanding of thermoplastics and thermosetting composite resin systems.

SUPERSONIC RESEARCH

Increased emphasis should be placed on developing the technologies required to achieve efficient, long range supersonic cruise capabilities. Studies which address economic and noise issues should be updated to identify technologies that have large potential payoffs and how they may be integrated into a transport or bomber confirmation. It is important to conduct system studies with such a vehicle in order to encompass the synergistic effects of various technologies—whether or not, the vehicle selected is the one that finally goes to product. It is important to note that the output of such research and generic technology for supersonic flight applies equally as well to a commercial or military transport as a fighter or a bomber. The research prepares us for our future in aeronautics. It is too late to start thinking of research at the time when the commercial market is ready or the defense system has a need for such a vehicle. Our "Nation's Homework" must be done now.

GENERAL AVIATION

The funding level in this area appears to be slightly limited. Large potential improvements for general aviation are possible through continued research, particularly in the technology of small, highly efficient engines.

COMMENTS ON THE REMAINING BASIC PROGRAMS

The remainder of the NASA programs—which, by funding, probably represents more than 90% of the total—are also very excellent programs which, in my opinion, the factors of funding, timing, goals, etc., are in balance.

Briefly, these include, but are not limited to:

Laminar Flow Control/Viscous Drag Reduction which offers potential fuel flow reductions of up to 25 percent.

Advanced Turboprop propulsion Systems which can provide a 20% reduction in fuel flow plus the advantage that this technology could cause a new generation of aircraft to be developed. Such an aircraft would then, obviously, incorporate many of those technologies which offer smaller potential (2 to 5%) but by themselves could never justify a new aircraft. Thus, large gains in total aircraft efficiency are possible because of turboprop technology.

NASA's Facilities have made an extremely significant contribution to aeronautics. These research facilities have a replacement value of about $10 billion. They are truly a national treasure! The industry does not and cannot duplicate these facilities. It is an area which receives the highest support by the entire aeronautics industry.

NASA's R&T base is well planned and in general, receives my full support.

In summary, NASA is doing an excellent job. It has, over the years, made significant contributions to aeronautics. The partnership of NASA/Government/Industry has, and is continuing to, work successfully. However, the advances in requirements, complexity, and cost of our aeronautical systems are such that the current level of NASA research funding falls short of that required to maintain our world position. Aeronautical research is the most efficient method of assuring this nation's preeminence in the field of aviation. This was also the opinion of an Aeronautics and Space Engineering Board study conducted under the auspices of the National Academy of Sciences in the summer of 1980.

NASA's programs are basically on the right track, but if additional funding is not available, there should be some internal transfer among programs to provide a better balance of content when one considers the useful output required for our nation's next generation of both civil and military aircraft.

As I stated in my testimony two years ago, industry cannot on its own provide the leadership role in aeronautics research. It needs government/NASA support, particularly for long term, high-risk technology programs. I believe that industry and NASA working together, with increased Congressional support, can provide the research base to maintain our preeminence and attain our goals in aeronautics. Without such additional support we must accept the fact that the U.S. will gradually relinquish its leadership.

I wish to thank this Committee for giving me the opportunity to express my views on this most important subject.

[The following information was subsequently received for the record:]

Questions of Senator Gorton and the Answers

Question. Can industry develop the relevant composite technologies in support of this subsonic transport goal?

Answer. Generally speaking, yes. However, it will occur with significant time delays which could impact the effect on the marketplace.

An important consideration in the competitive position that the U.S. aircraft industry face is that all of the foreign manufacturers are government-owned and government-supported companies, receiving regular government funding for the development of technologies and production of civil aircraft. The U.S. manufacturers enjoy so such support.

The U.S. aerospace industry has, and will continue, to develop new technology and apply it to its new products. However, without the support of the ACST program, the development of the relevant composite technologies will probably slip 5 years.

Question. Can industry accomplish the same technology objectives as the NASA program related to primary composite structures, only at a slower pace?

Answer. The NASA ACST program was established because engineering and manufacturing technologies as related to advanced composite materials have not been developed to the level required for the application to primary composite aircraft structures. In order to achieve the full benefit of composites relative to aircraft performance and cost, composites must be applied during the initial design phase of an aircraft development. The ACST program was structured to develop a composites primary airframe structure technology base that would permit the achievement of the full potential of weight, fuel and cost savings for the next generation of civil and military transport aircraft. With the successful completion of the ACST program, sufficient engineering and manufacturing data would have been generated and disseminated to the aircraft industry to provide confidence to utilize composites in primary aircraft structures. This technology base would have been available in the late 1980, early 1990 time-frame. There's no question that the industry can accomplish the same technology objectives as the above program but the important factor is that the technology may not be available in time for application to the next generation of civil and military aircraft.

One element of the NASA composite programs has been the dissemination of the advanced composite structures technology developed by Lockheed, Boeing and Douglas to the aircraft industry at large. Without the benefit of this element of the ACST program, the cost and time required for the development of the composites technology will greatly increase. The NASA/industry approach is an efficient use of R&D resources. Each company developing the technology on its own inherently results in duplication of resources, whereas, in effect, the original NASA program pools resources and shares technology across all the industry.

Question. What is the appropriate role for the government if this technology is to support a national aeronautical goal?

Answer. The role that NASA has undertaken by funding and supporting the Aircraft Energy Efficiency program (ACEE) and the Advanced Composites Structures Technology program (ACST) is still appropriate for the government in the support of the national aeronautical goal. The ACEE program provided the aircraft industry with timely technology to confidently apply advanced composite materials to control surfaces and empennage structures, active controls to wing design, etc. The ACST program would have also provided the technology to the aircraft industry, at the time it is needed, to confidently apply composite materials to primary wing and fuselage structures.

Question. How can the $24 million investment to date in NASA's Advanced Composite Structures program be maximized?

Answer. The ACST investment of $24 million for fiscal year 1984 and 1985 can only be maximized by the continuation of the ACST program. However, the data that has been generated under the ACST program for the application of advanced composites to both wing and fuselage structure has been and will continue to be utilized throughout the aircraft industry. The fuselage and wing key technology programs are providing a technology foundation for the aircraft industry to build upon for the design and fabrication of composite structures. This data bank, through technology transfer requirements inherent in NASA programs, is available for the aircraft industry use.

Question. Should we be doing more in this area?

Answer. Yes. Anytime one gains additional knowledge from research without incurring expenditures, it must be considered a windfall. Further, such information provides valuable insight with respect to the strategic plans of the competition.

Question. On the other hand, is our technology too available to our competitors?

Answer. Yes, but as I am sure you know, it is a difficult problem to solve. Various groups, over the past 5 years or more, have attempted to find a practical solution but have been unsuccessful. Too much restriction limits our growth in a technology and, yet, an open policy affords the competitors a tremendous resource of knowledge, as stated in the previous answer. I wish I had the answer, but I do not.

Question. Is NASA adequately supporting the technologies that will lay the groundwork for a supersonic transport?

Answer. The adequacy of NASA support can only be judged on the basis of the potential timeframe of a supersonioc cruise transport development program. Our new national aeronautical goal for such a vehicle needs a more specific date. Goals without specific dates are not usually met, or meaningful. Current support must be considered inadequate for the initiation of a development program in the early 2000's.

Initiation of such program by an airframe manufacturer will not take place unless substantial assurance is obtained that the supersonic cruise transport can be economically viable and that it will be satisfactory from an environmental standpoint. Much work needs to be accomplished to achieve this position.

Question. If not, what should NASA do differently to support this goal?

Answer. All areas of the fundamental technologies of aircraft design would have to be enhanced. For example, basic materials development of advanced aluminums, intermediate temperature composites, and metal matrix materials should be expanded. Aerodynamics, control systems, propulsion systems, sonic boom, load alleviation, etc. all require further support if our goal is to be met. It should be noted that this research would apply equally as well to military aircraft.

Statement. The third goal in the White House report on national aeronautical R&D goals concerns tranatmospheric transport.

Question. How soon is there likely to be a national requirement for such a capability—will it be largely civil or military?

Answer. There is an immediate national requirement for transatmospheric flight capability in a military intelligence role. If the capability were available today, it could be put to immediate use in quick reaction single pass overflights of a territory where deep penetration and near complete immunity from defenses are required. Short arrival time over sensitive sites allows little or not time for activities there to be concealed. This same performance capability also permits capitalizing on clear weather opportunities over target sites usually obscured by cloud cover from optical surveillance. Aircraft lack the range, speed and survivability to accomplish such missions. The missions can be done by satellites launched on expendable boosters but booster costs are formidable and the satellite's value after its first pass is largely compromised by the predictability of its orbit. A new satellite and launcher must be expended each time a surprise look is needed.

Fully reusable vehicles which can be launched on demand on a sortie basis like aircraft, but which have orbital or suborbital performance would fill a gap in current intelligence-gathering capability. Many missions are envisioned where application of precision nonnuclear weapons to geographically remote or heavily defended targets would achieve important tactical goals. Transatmospheric vehicles would perform such missions at acceptable sortie cost with minimal risk.

Given the development of transatmospheric vehicle technology for military use, civil applications would follow. Currently there is considerable competition for the commercial space launch business. Several U.S. private enterprises are entering the market. The availability of technology affording reusable launch vehicles with attractively low turnaround costs would probably allow growth in civil space applications similar to that experienced by commercial aviation with the infusion of military developed jet aircraft technology.

Question. How much would it cost to develop this capability and over what period of time?

Answer. Development cost and time estimates vary according to the level of technological sophistication perceived necessary for the first generation vehicle. Lockheed is convinced that in response to a national requirement a reusable horizontal launch and landing single-stage-to-orbit vehicle with useful payload capacity could be flight demonstrated 5 years from go-ahead at a cost of roughly $5 billion using a Skunk Works approach. This vehicle would exploit technology sufficiently well in hand today to put program risk at an acceptable level.

If the decision is to wait for next generation technology, particularly in the fields of high temperature materials and advanced propulsion systems, then the development period must be on the order of 15 years, with a price tag of approximately $20 billion.

Question. Do NASA's present and projected budget requests adequately support these transatmospheric technologies?

Answer. NASA budget requests omitting the Space Shuttle Main Engine (SSME) Phase III improvement program will definitely not support transatmospheric technology development. Any near term transatmospheric concept will probably need to rely on SSME derivatives for propulsion. This is the most advanced liquid rocket engine available in the required thrust range and should be developed to its full performance and service life potential for future applications.

Apparently NASA budget requests have not anticipated transatmospheric technology needs nor regarded them with the urgency that our new national requirement would call for. Specific funding directed toward Shuttle improvement programs could accelerate the availability of technology which would be invaluable to transatmospheric vehicle development even though it may never be incorporated into the STS.

Question. Can we make significant advances in subsonic, supersonic and transatmospheric aeronautics as national goals with a NASA aeronautics budget that continues to grow at a rate no greater than inflation?

Answer. I do not believe we can. Development costs for advanced aeronautical projects are escalating much more rapidly than indicated by inflation. Our industry is already losing ground in subsonic aircraft; supersonic technologies have languished for some years and need substantial investments; and transatmospheric vehicle technologies need large increases in budget if we are to establish the required technology base to meet our new goals.

Question. What kind of increases in NASA's aeronautical R&D budget are necessary to permit these goals to become a reality?

Answer. As I stated in my earlier testimony, I believe the aeronautics budget must be increased by at least $100 million per year, as compared to the current levels. If this cannot be accomplished, we must reduce our nation's goals. We should not deceive ourselves; the facts are clear—the U.S. position of preeminence in aeronautics is evaporating. This deception can be done quite easily—we rationalize that our technology readiness dates can slip and, therefore, funding is really sufficient. One usually sees the falacy in this approach after the market has already been lost. Let us either fund to meet our goals or be more realistic in our expectations.

Question. Wnat can industry do to support these goals?

Answer. Industry is doing a great amount now in terms of substantial cost sharing on research programs. But, obviously the total effort (industry and government) is inadequate—the market is eroding. This problem is compounded by government actions in recent years whereby industry is unable to recover its full expenditure of Independent Research and Development costs as mandated by law. Industry is forced to accept ceilings for cost allocation at levels significantly below planned expenditures. Industry must have support from Congress if America is to maintain its technological level in aeronautics and remain competitive in aviation manufacturing.

Question. With one industry team planning to conduct a flight test of its counter-rotation turboprop technology in 1986, does this in any way reduce the justifications for NASA conducting a flight test of the single-rotation configuration, after the industry-sponsored test?

Answer. The currently planned NASA/industry program provides technology readiness not available through the program you refer to. It provides data to validate methodology for predicting blade stress as a function of the surrounding flow field; provides data for understanding propfan source noise, evaluates promising techniques for controlling cabin noise and develops an understanding of the structural and airborne paths by which this noise enters the cabin. It develops basic methodology useful to single or counter-rotating props, ducted or unducted configurations. All data, methodology, results, etc. will be available to industry—it is a very generic program.

Question. Mr. Hopps, in your testimony, you have questioned the level of funding and the scope of NASA's Oblique Wing program.

Since NASA will use an already-developed one-of-a-kind testbed vehicle that will require only minor modifications, shouldn't we take advantage of this opportunity?

Answer. It is important to understand that because of budget limitations, there are already technical areas in which NASA can not adequately conduct the basic research that could significantly affect the ability of our nation to regain preeminence in aeronautics. It is this fact that makes it difficult to justify spending several million dollars on an oblique wing test-bed where the results obtained will have practically no value to the industry. But, several million dollars would do much to satisfy the needs of the rotorcraft industry, for just one example.

It is argued that the oblique wing test-bed would advance the state-of-the-art in control systems and help understand the flying qualities and structural considerations of such a vehicle. But, no aeronautics expert doubts that a control system can be developed to provide satisfactory flying qualities, etc. for the oblique wing vehicle. The problem with spending money in this program is that almost every problem associated with this flight article will be uniquely associated with this particular airplane. And, what do we have when we are done? Nothing that won't have to be redone if such a vehicle is ever developed! Further, flight research is usually conducted when there are unknown effects of scale involved. This is not the case with the oblique wing. It should also be noted that in 1984, and again this year, the NASA Aeronautics Advisory Committee placed the oblique wing test-bed program in the low priority category.

In these times of difficult budget constraints, we must have the courage to weed out low priority programs and place the money where it will be most effective. There are always a "lot of nice opportunities, new facilities that would be used if built, etc.", but it is mandatory that we prioritize. We cannot do everything. Let's do a much better job on fewer research endeavors—but it be those research efforts that the industry needs in order to regain and maintain a U.S. preeminence in aeronautics.

Question. What would be the likely impact on our civil and military rotorcraft industries if NASA were to terminate this Systems Technology program?

Answer. The rotor systems technology was to provide the helicopter industry with the development and demonstration of improved technology for the reduction of helicopter noise and vibration and for the application of digital avionics to the problems of helicopter instrumentation and control. If this program were terminated, several critical impacts would occur.

First, the joint NASA/industry/FAA program to reduce external noise of helicopters to meet targeted FAA certification requirements would stop. There is no other industry or DoD effort currently directed to the noise problem beyond some very fundamental research activities in the universities and Army laboratories. Without this improvement, civil and public service helicopter usage in confined area will become more constrained by community opposition. It is quite probable that the initiation of new civil helicopter programs by the U.S. industry will be significantly curtailed if these uncertainties in ability to meet certification and community noise requirements remain unanswered.

Much needed advances in vibration control technology will not be available. Recent major military helicopter program have suffered budget and schedule problems in attempting to solve the problems of vibration control; it has been a cut-and-try methodology. Heavy devices to suppress vibration were required; payload efficiency was reduced. Available technology is just inadequate. The Army has some work underway on the rotor excitation portion of the problem but only NASA is investigating the airframe response portion. There is an urgent need to acquire a data base and conduct the correlations necessary to verify the analytical codes being generated for rotor excitation and airframe response and the interaction or coupling between these two factors. It is estimated that more than half of the problem lies with the unpredictability of the complex dynamic response of helicopter airframes, and NASA with its airframe finite element analysis is particularly qualified to help. Therefore, if NASA R&D programs on airframe dynamic airframe analysis technology are terminated, it must be anticipated that many times the properly focused R&D investment will be dissipated on repetitions of the vibration development problems experienced in the past.

Finally, although NASA does not now have a systems technology program in the area of digital microelectronics for improving controlability and extending mission capabilities, it was hoped that such a program would be initiated. Without NASA funding, next generation U.S. military helicopter programs will not be able to exploit with confidence the full potential of active controls and progress may be limited in the pilot safety record of civilian helicopters.

Quesiton. Statistics indicate that our foreign competition has captured a growing share of this rotorcraft market. To what extent is this trend likely to continue?

Answer. The trend is expected to continue. U.S. helicopters must not be just equal, but they must excel in technical capability, in order to overcome the political and other disadvantages which occur in most foreign markets. But, a technology leveling has taken place. A new infusion of technology is required. Market opportunities exits for quieter, smoother, more efficient helicopters. But, research is required. Yet in the past three years the research funding to exploit these opportunities has collapsed.

It should be noted that in spite of the large prior investment in U.S. facilities for rotorcraft testing and development our advantage is beginning to rode. In the critical area of noise, the helicopter industry goes to Europe for a wind tunnel facility quiet enough to adequately research the rotor noise problem. Our eroding position does not stop here. The French have move ahead in technology of rotor icing and have certified the first civil helicopter for operation in icing conditions. This will provide them a distinct advantage in the marketplace.

As stated earlier, there are significant needs identified by the aviation industry. We must prioritize—eliminate the weaker or unwanted programs—and increase funding in the more important areas, or our goals will not be attained.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS

Question. If, because of budgetary constraints, the Congress cannot significantly increase funding in FY 1986 for NASA aeronautics, what steps will industry take to ensure its continued place as the leader in the world aviation manufacturing market?

Answer. If Congress does not significantly increase funding in FY 1986 for NASA aeronautics, it is my belief that the position of the U.S. aviation industry must continue to erode in the world manufacturing market. The extensive and ever growing rivalry from foreign competitors, most if not all of whom are heavily financed by Government subsidies, is a financial challenge that U.S. industry cannot meet. Witness the efforts by American manufacturers to remain competitive through joint-venture arrangements with foreign firms that contemplate manufacture abroad. The dilemma is further compounded by government actions in recent years whereby industry is unable to recover its full expenditure of Independent Research and Development costs (despite the mandates of P.L. 91-441). Industry is forced to accept ceilings for cost allocation at levels significantly below planned expenditures. Industry must have support from Congress if America is to maintain its technological level in aeronautics and remain competitive in world aviation manufacturing.

Question. Would you please tell the Committee how the proposed elimination of the Advanced Composite Primary Structures program would affect ongoing work at Lockheed? If this program is terminated, will Lockheed continue its work in this area?

Answer. Lockheed is committed to the development of advanced composites technology. The Lockheed Corporation has supported the development of this technology over the last five years through the expenditure of over $35 million of in-house funding. Lockheed's commitment is further demonstrated by the initiation of a company-funded program in mid-1983 dedicated to the development of advanced composites technology. This in-house program, which is being conducted jointly by the Lockheed-California and Lockheed-Georgia Companies, coupled with the NASA ACST program, provides funding in excess of $43 million ($26M NASA, $17M Lockheed) dedicated to the development of composites primary wing structure technology.

With the termination of NASA's ACST program, Lockheed will continue to develop needed technology with reduced in-house funding and will also actively pursue R&D contracts with NASA. Because of the reduction of funds, emphasis will be placed upon engineering requirements with manufacturing activities reduced to developing low cost manufacturing concepts. But, without the fabrication of the full-scale wing box specified in the ACST program, manufacturing technology will be severely curtailed.

Question. Lockheed is also the lead contractor for the Advanced Turboprop Program. Can you please outline the project and Lockheed's primary objectives?

Answer. The basic objective of the program is to provide technology readiness for the propfan. It will verify the structural integrity of large-scale blades, evaluate source noise and cabin noise. Major tasks include the aircraft design modification and conducting full-scale static tests of the complete propulsion system with respect to functional compatibility; a full-scale test of passenger cabin noise and a flight test to evaluate and correlate the propfan structural integrity and noise characteristics with developed codes. The data and results will be available to the industry.

Senator GORTON. Mr. Hopps, that was a very eloquent statement. Earlier on, you spoke about the real need in this whole field for $100 million more than was in this budget. Would you take that $100 million if it had to come out of other elements of the NASA budget, even if they were elements which involved contracts with Lockheed?

Mr. HOPPS. In other elements, do you mean space?

Senator GORTON. Yes.

Mr. HOPPS. I just moved over to the corporate office. I do not as yet know the needs of the space programs. If I were sitting here a few months from now, maybe I would be making the same argument for funding. I have to just say I don't really know what the space needs are.

Another year from now, if you ask me back, I will be prepared to answer that question.

Senator GORTON. I asked that question and I would like comments from all of you based on—each of you makes a very forceful statement, but in most cases, what you are telling us in a very thoughtful and sophisticated fashion, is exactly what every group who comes into my office on any program tells me, whether it is Amtrak or Food for Children or whatever.

Now, last night, the House Science and Technology Committee reported the President's budget for NASA to the floor. It was overwhelmingly cut back to a level of a freeze. That is to say, the number of dollars available in this current year, the dollars for this current year, obviously at that level cannot go forward with something like the space station which has a rapidly ascending cost.

And we should take money below that freeze level from some other programs, at this point undefined. The House pretty much has said this is how much we are going to spend.

I guess I would like the help of all of you in telling me if we have to go below what the President recommended. Frankly, it looks to me right now as though it is the fact we are going to be facing, whether I want to or anyone else wants to, because that is going to be the reality.

How do I set those priorities? I guess I will leave you each 1 minute or so to comment on that. We can start and go right across the table.

Mr. HOPPS. Well, I would go back to the fact that again programs like computational fluid dynamics, which are a tool and very important, still are not going to contribute significant to the market needs of the 1990's. But, composites and advanced metals certainly will. And so will supersonic research. There are opportunities in both military and commercial applications; some are beyond the year 2000 in the commercial field, but the opportunities are there.

Additional work on advanced engines is required; it that is still the key to the future products. I still do not think we have the priorities right in this total money, and I think the programs you heard about in here are the ones that should even be beefed up if we have to do what you said and accept that we have to have the technology ready by 1990 for the year 2000 and for the airplanes that are going to be in service in 1992, that technology has to be flowing out now, within the next few years. And I do not really see it coming out that fast.

Senator GORTON. Are you telling me we have to cannibalize the distant future for the immediate future?

Mr. HOPPS. No, sir. I believe if we are to limit ourselves to the current funding, we should examine less things—the large market potential items—and do a better job in each of them. We must concentrate on the high priorities, put more money and effort into those technologies that the industry believes are needed for the 1990's and the early 2000's.

Mr. SCHAUFELE. My answer to your question, Senator, on how to deal with the priorities of a constant or decreasing NASA aeronautics budget, makes me want to recommend going back and reviewing the balance that we have in the program between what NASA calls its R&T base and its systems technology activities.

For the long haul, you have to have adequate efforts in R&T base. You have to really look at all the potential emerging technologies. You have to look at a lot of them that haven't really developed yet, and let the research within NASA really wring those things out.

But what I fear is that with significant pressure on the budget, that the critical step of systems technology, which allows the small scale R&T base effort to be validated for application and to be useful to the industry will be the target for budget cutting, and I think that would be a serious mistake because it just delays the applicabilty of that technology and has a major impact on the industry's ability to produce superior products.

Senator GORTON. But you and your competitors won't make up for it?

Mr. SCHAUFELE. We are not able to do that. We are just not able to invest the resources, although. we have contributed significantly in previous systems technology programs with NASA. But if we have a void of several years where this type of activity is really diminished, it is going to have a real impact, not today and tomorrow, but 5 to 10 years downstream when the products that would utilize the advanced technology should be coming onstream and they will not be available.

Mr. KIRCHNER. Mr. Chairman, I would like to present my answer to your question. Certainly Roger Schaufele has a very good point. However, if we are in a situation of limited funding, there is no doubt in my mind that the primary role of NASA is more in the R&T base, and the systems technology work should be done to the extent the Nation can afford it.

I would agree with Roger's conclusions as to the effect, but I still believe that is fundamentally correct, and therefore I would personally submit that we should support the R&T base.

For example, in the composites area, it was the systems technology that was zeroed out by the administration and it was the R&T base that they were tending to preserve. If we are going to cut out that much systems work, let's put relatively more into the R&T base. I think there is that much valuable work to be done, and we will not be jeopardizing our long-range future for something short term.

Obviously, as Mr. Schaufele says, industry will find it difficult to substitute for some of this systems technology that will be canceled out. But on the other hand, industry does have the option of working in those areas that are important to the individual companies.

Let's go on to the turboprop. The turboprop is a systems technology that is a high priority on NASA's budget. Well, if you cut out or reduce the systems technology aspects, you are going to save a lot of money. I am not saying that we should do that. But if you did, you can do a lot more R&T base work including all of the technical parameter variations that I previously mentioned—and Mr. Hopps mentioned—than you can in a systems technology program.

So I would be for going heavy on R&T base. Now, I think there are other priorities that become clear at the same time. We talked about the altitude wind tunnel. Now, here again, it is a matter of judgment. NASA's judgment is that they would like to activate the altitude wind tunnel at some time in the future, and, as you mentioned before, there is about a million dollars or so going on for planning purposes right now.

Most of those in industry that I have talked to feel that that is a marginal choice. Most of the committees and industry observers I have talked to say that, if they were limited in total national budget, they would place other priorities higher than the altitude wind tunnel. Not that it doesn't bring to the country certain capabilities that do not exist or are expensive to develop in other ways, but, on balance, that is just a judgment. Not only will it take $160 million to develop it, but it is going to take a lot of work and subsequent funding to justify its continued use.

Take the oblique wing. The oblique wing is a development of a system; and I am the last one, like Mr. Hopps suggests, subsequently to suggest starting programs and then subsequentially stopping them, because I really believe that is a waste of money, too. In a lot of programs where we are trying to save money, that is the case: We start them and then we stop them, and it really hurts to see that. I would be the last one to promote that kind of management.

But the oblique wing in our view has no commercial application. We believe it is a Navy program. We believe that if it is going to be a Navy product someday, the Navy ought to developed it. But that is our just our judgment.

So we believe that there are a lot of sources for reducing or, let's say, tightening the belt and therefore reprioritizing.

Thank you.

Senator GORTON. Dr. Krone.

Dr. KRONE. Thank you. In my opinion and I will try to give a direct answer to it, I think that what we are talking about here, generally speaking, is under the conditions of the tight budget, whether the NASA budget should have an increased emphasis in aeronautics at the expense of the space programs if the total budget can't be increased. I think that under the circumstance that the percentage is currently heavily weighed for space, that would be a viable thing to do.

And the reason I say that is that basically what we are talking about here is a huge optimization problem. You have to determine what your measure of merit is when you talk about optimization. I think the measure of merit clearly is the return on the dollar to the country and benefits in the future on the economic side as well as the military side.

The security of the country is also involved in the aeronautical programs. And in my opinion, and in pretty much the opinion of the group I represent, the return on the dollar on the aeronautics side is greater, a dollar increase in aeronautics is going to return a rather large number of dollars in the future.

Now, relative to the so-called systems programs as opposed to the R&T base programs. In the written testimony that I submitted, I talked to that point. I think they are inseparable. I think that when you are performing your laboratory work, a very necessary element of that work or step progression for that work is the large technology demonstration programs or system programs as they are called. The reason being that for one thing, you have to put a technology, especially when it is advanced to a rather high stage, to a real world test. Real world tests do not exist in the laboratory. To be perfectly blunt about it, and if you want to get the benefit of the R&T base programs, you have got to consider these technology demonstration programs as a link to the production, and what becomes the real economical or military benefit.

From my experience, I can say that high technology, advanced technology, does not get translated into a production prototype program unless there is a real world demonstration. There is generally too much risk involved to do that.

So I would say that even under the circumstance of not being able to add money to the total NASA budget, I would certainly recommend increasing the aeronautical side.

Senator GORTON. Dr. Shank.

Dr. SHANK. I would like to say two things. I shall restrict my remarks to the propulsion part of the aeronautics budget because Pratt & Whitney is in the propulsion business. I do not feel competent to comment on airframe programs.

All of the NASA committees and National Research Council committees on which I have served over more than a decade, have advocated a strong R&T base. The R&T base should be emphasized.

In the real world, though, it never has been possible to bring about a large augmentation in the R&T base portion of the NASA budget. Also I believe that how we judge R&T base budget versus the systems budget becomes problematical. To cite one example, the Hot Section Technology Program [Host], is classified as a systems program. However, it is producing as much fundamental technology as any program in the propulsion area.

The work resulting from the Hot Section Technology Program has helped us to better understand what is occurring in the hot section of the engine. The hot section of the engine is the most costly section of the engine, and it absorbs about 50 percent of the maintenance costs in service.

Host Program results are being applied to the design of new engines. Thus we can say that output of Host is finding its way into commercial service.

Thus we have to be very careful about making arbitrary judgments as to what are systems programs and what is R&T base. The two are inextricably mixed.

Also, I wish to make specific comments concerning the planned 1987 NASA turboprop flight test. It is a flight test of the NASA propfan, the origins of which go back a decade. NASA has invested 10 years of R&T work in developing the propfan.

In this flight test we are talking about propulsion. This propeller, or propfan, as it is called, made people realize how high turboprop propulsive efficiency could be with the right kind of propeller.

I think in the long term, past 1986, 1987, and past the 1990's, this propulsive device developed by NASA has the potential to exceed anything else it is being compared to today. To abandon this opportunity to obtain basic information is fundamentally shortsighted and would cut us off from the technology that could flow from it.

Senator GORTON. Thank you.

Mr. Kirchner.

Mr. KIRCHNER. I would like to comment on Bud Shank's remarks. He said one thing that I really agree with, and I would like to clarify my own views. When I mentioned systems technology, I agree that there is a lot of R&T base work included in those systems technology programs.

As far as I am concerned, all of that work does qualify as R&T. So we do have a bookkeeping problem here. It is true in most of our systems technology programs, as he points out. For example, the composites program had a lot of what we would call R&T base work in it, in addition to the large component work.

So I am speaking generically when I refer to systems technology work. I mean the commitment of a lot of funds for, let's say, a single end item as opposed to the technological research that might go on in support of it. The typical NASA systems technology programs are a mixed bag. So, I am talking about what is really research versus, let's say, single end items.

Thanks.

Mr. HOPPS. I would just like to make one point supporting what Mr. Shank said regarding the turboprop. To understand the importance of the turboprop program one should look back at the whole family of commercial jet aircraft started by the 707 and the DC-8; the jet engine and the swept wing were the new technologies, but the propulsion system was the key. The wide body aircraft started with the 747 where the high bypass ratio engine was, again, the key.

I believe the turboprop has the potential of starting a new family of aircraft, and when you start a new family, the attractive feature is that the aircraft designer will employ composites, active controls, artificial longitudinal stability—that is, those technologies that in themselves cannot justify a new airplane, but each such technology can bring another 3 to 5 percent to the table to produce an extremely efficient vehicle.

When you can build a new airplane, it is then that you can use all the NASA technologies; that is the key to the development of a whole new family.

Senator GORTON. Thank you all very much. I have a whole series of additional, much more specific questions, and I suspect some of the other members do. We would like to submit those to you and have your written answers.

You have the honor of having been the last panel to testify on the NASA authorization bill this year. It has been a most interesting one, and now we have to go to work and do something with it.

Thank you very much.

[Whereupon, at 11:53 a.m., the hearing was adjourned.]

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

STATEMENT OF THOMAS M. DONAHUE, CHAIRMAN, SPACE SCIENCE BOARD, NATIONAL ACADEMY OF SCIENCES

Thank you for inviting me to appear to testify before your Subcommittee. I am sorry that I was unable to appear personally but appreciate having the opportunity to submit my written remarks for the record. As you know, I am the Chairman of the Space Science Board of the National Research Council. The Board is charged with advising NASA and other elements of our government with responsibility for our space program about scientific issues in that program. In carrying out that charge I have the pleasure of interacting with your subcommittee every year at about this time in order to discuss the President's budget proposal for space science.

This year we certainly have to commend NASA and the administration for sending to you a forward-looking proposal for the agency as a whole and for space science in particular. There are increases in virtually all lines of the budget. For example, this year we do not have to request you to restore cuts in Research and Analysis or Mission Operations and Data Analysis to levels. In the past few years the levels requested were in some cases lower than those that you authorized and appropriated the previous year. We want to thank you for your persistence in keeping these vital programs visible in the past and to congratulate the administration for adopting that policy this year.

This coming fiscal year should be a great one in many ways for our space science program. Missions launched in years past, such as Pioneers 10 and 11, Pioneer Venus, Voyager, The International Comet Explorer (ICE), the Active Magnetospheric Particle Tracer Explorer (AMPTE), and the Solar Maximum Mission should still be providing valuable information about the solar system and the universe: ICE will encounter the comet, Giacobinni-Zinner, this September; Voyager 2 will arrive at Uranus to provide us with our first close look at that planet. The Hubble Space Telescope will, we all hope, be launched. So will Galileo and the European Ulysses spacecraft which should be on a first class mission even though it has been deprived of its very important American counterpart.

After saying all of these good things it is embarrassing in this year of fiscal stringency that I cannot pretend that everything about this budget is superb. It is a truism that space science cannot survive without flight opportunities. There are none offered in the 1986 budget. New starts for the Ocean Topography Experiment (TOPEX), for the International Solar-Terrestrial Program (ISTP) and for Gravity Probe B have not been requested. In a normal budget year you surely would have seen proposals for at least two of these. This is not a normal year, and we recognize the economic and political factors which influenced this decision. However, it is clear that postponing the initiation of these missions will create a very great traffic jam in future years. The Advanced X-Ray Astronomy Facility (AXAF), the Comet Rendezvous and Asteroid Fly-By Mission, the Geopotential Research Mission (GRM), the Space Infrared Telescope Facility (SIRTF), all are well studied missions designed to address questions of high scientific priority that are also waiting in line. If I take the optimistic view that the ban on new starts will be lifted next year, as I must, then I must strongly recommend that a careful plan be developed to get these missions underway—along with at least one more solar system observer mission on the Solar System Exploration Committee's list—during the next five years.

These highly visible large projects are not the only ones being delayed. It is also very serious that we just don't seem to be making satisfactory progress in getting small P-I class experiments flown on the shuttle at a high rate (or any rate at all). Nor do we see long awaited announcement of opportunity for new Explorer missions, or satisfactory progress in developing the approved Extreme Ultraviolet Explorer (EUVE). Thus space science is still suffering from the lack of flight opportunities that can be traced back to the delays in getting the shuttle operational and make it so difficult to maintain coherence in academic space research programs or in an industrial base of support.

One last complaint and I shall return to a more positive tone. I note that of the three recommendations of the NASA-University Relations Committee, only the one for Graduate Student Fellowships is being implemented. The supplemental appropriations for laboratory equipment and for data analysis were not forthcoming last year and are not to be found in this budget request either. The result is that university laboratory equipment which was in a state of almost serious obsolescence a couple of years ago is in a state of even greater decrepitude.

On a positive note I can report to you that our Committee on Solar and Space Plasma Physics has completed a planning exercise for its disciplines, similar to those carried out by the Astronomy Survey Committee and the Solar System Exploration Committee. Its report, entitled "An Implementation Plan for Priorities in Solar System Space Physics", is presently being reviewed by the NRC and we shall be eager to let you have its recommendations as soon as that process is completed. The report outlines a prioritized program for future missions and analysis activities through the year 2000, which is characterized by stability, feasibility, and affordability. The scientific community in this area, like those involved in the planetary and astronomy exercise has tried to face up to the hard choices of putting together a program which addresses only the highest priority science within a realistic budget level. Its major elements involve both exploration (for example, a probe to the vicinity of the sun), and intensive studies of the chain of interaction from the sun through the interplanetary medium to the magnetosphere, ionosphere and upper atmosphere of the Earth (for example, the upper atmosphere research satellite (UARS) and the international solar terrestrial physics program (ISTP)). Thus, the space science community now has in place a road map for a national research program in solar and space physics, a program that complements those in astronomy and planetary exploration.

Looking ahead further into the future—a decade or more ahead—I see brighter things. The Space Agency established a committee under Professor Peter Banks of Stanford University to advise it concerning how to configure the Space Station so that it would be useful for science. The Space Science Board has followed the work of this committee closely and is very pleased with the wisdom of the advice it has generated. We sense a strong commitment on the part of Mr. Beggs, Mr. Culbertson and Dr. Edelson to heed that advice. If they do, the Space Station should provide a very useful base from which we shall be able to servcie, maintain, and refurbish the space science platforms and free flyers of the future, where large complex structures can be assembled and launched and where exciting scientific studies in life science and some physical science disciplines, such as cosmic ray physics can be pursued. As long as all involved remain committed to these positive properties of the Space Station, and determined not to compromise science requirements by artificially distorting them to match the convenience of some particular Space Station architecture we should arrive at the mid-nineties in good shape. As I have repeatedly stated, however, this will be true provided space science missions continue to be carried out at a reasonable rate between now and then.

Looking even further ahead I can report that the long range study that we were asked to undertake in order to identify the directions that major efforts in space science should be taking in the two decades after 1995 is well underway. Task groups have been formed in astronomy and astrophysics, in solar system exploration, in solar and space plasma physics, in life sciences, in earth sciences and in relativity and basic physics and chemistry. They have met for ten days last summer and three days in January. Their work will not be finished until June of 1986. However, it is already clear that stretching ahead as far as we can see, a space research program could readily be justified on purely scientific grounds that is much more extensive than any likely to be allocated the resources needed to support it. We should be happy to brief you on our progress in more detail at any time.

The Space Science Board is often asked to comment on the balance in NASA's space science program. This is easy to do if one or more disciplines that represent good science are receiving such an inadequate share of resources that their viability is threatened. For example, Space Plasma Physics may drop to this level if ISTP does not get underway within the next couple of years. Solar System Exploration was threatened with extinction a few years ago. Within a discipline—astronomy—the high energy community has been starved for data too long. These are examples. In cases like these it is relatively easy to arouse the entire scientific community to support the ailing member and restore balance in this sense. But whenever we address the question of whether a body like the Space Science Board with its representatives of all space science disciplines could develop proposals for priorities across disciplines, we quickly conclude that there are no scientific criteria we could develop for the task. We are experts at setting priorities within any one field of science. This is what I think we do rather well. However, the astronomer, for example, finds it difficult to judge impartially the value of science missions in earth and life sciences relative to his own discipline. We are able to recognize the potential of fields not currently very active in using space science vehicles to develop strength by doing so and to encourage them by measures such as increasing the number of representatives on the Board or establishing a standing committee to develop science strategy. But it seems to us that the ultimate judgments about priorities, and whether balance is maintained as a result of exercising priorities, are made adequately by the present method of relying on a complex democratic process to make essentially political decisions. Fortunately, that process is a dynamic one and lends itself to regular appeal and adjustment.

In the spirit of playing our part in that process I should tell you that our greatest concern for balance in the space science program for the past several years has been with regard to the Space Plasma Physics discipline. Ever since a reorganization of the science management structure at NASA Headquarters occurred some years ago that deprived that activity along with Solar Physics of division status, there has been a concern in the relevant community that the interest of those sciences were not adequately represented at NASA. The community would probably agree that the test of the validity of its concerns is whether ISTP survives the hazards of the budget process during the next couple of years. There are many, however, who would prefer not to take the risk of failure and who press for administrative changes now.

Where administrative changes are concerned the Board is in general pleased with recent developments regarding science management at Headquarters. If a plan is implemented to make use of detailees from universities at NASA similar to the one in effect at the National Science Foundation, we feel that a good step toward stabilizing the science management process will have been taken.

For this plan, as well as for all of the other positive elements in the 1986 budget request, we congratulate NASA and commend the request to you.

STATEMENT OF MARK S. LYON, WASHINGTON STATE CITIZENS FOR SPACE AND THE INTERNATIONAL L5 SOCIETY

"The births of all things are weak and tender, and therefore we should have our eyes intent on beginnings."—Montaigue

Washington State Citizens for Space and the International L5 Society are pleased to be invited to testify before this distinguished committee. Last year, America embarked on a historic beginning, the endeavor to establish a permanent, American manned outpost in space. Much has happened in the year since. As the program moves ahead, some have naturally raised questions as to the directions which the program should go or the speed with which it should be pursued.

We heartily endorse a vigorous discussion of America'a space policy. While we ponder the questions, let us not forget the reasons for the space station project. The benefits to America from the space station program will be immense, and the time to act is now, lest the opportunity slip away. Too often protracted discussion becomes dithering.

"The secret of success is constancy to purpose."—Benjamin Disraeli

The nationally acclaimed study of American business by Thomas Peters and Robert Waterman, Jr., In Search of Excellance—Lessons from America's Best Run Companies, identifies a "bias toward action" as a key element in any successful endeavor. In case after case, the study shows how organizations which are willing to try a project succeed, whereas organizations that study, study, and restudy a project, in hopes of achieving the perfect solution, fail or succeed too late. This experience garnered from business guides us with the space station as well. The time to act is now. Debate on such questions as to the priority of uses of the space station, who should be sent to it, and the best way to manage it should and will continue. However, to delay the program pending the outcome of such debates will only increase the costs and delay the benefits of the project.

We must not let such management paralysis eclipse the opportunity for action.

"The only limit on our realization of tomorrow will be our doubts of today"—Franklin D. Roosevelt

Over two hundred years ago, Americans were amused by the parlor tricks possible with static electricity. We can all recall the tale of Benjamin Franklin's kite and the electrical storm. But it has been the fundamental scientific understanding of these parlor tricks which has led to the technology we now take for granted. Our civilization is founded on the science of electromagnetism—lights, motors, television, refrigerators, and computers all rely on electricity.

For many people, space is also a "parlor trick". But today's parlor tricks are tomorrow's high tech. The space station programs is the next step toward harnessing the principles behind tomorrow's civilization.

"Half the failures in life arise from pulling in one's horse as he is leaping."—Julius and Augustus Hare

Others in the world are awakening to the opportunities of space. The Soviets have been flying space stations for over a decade. The Europeans, Japanese, and others are announcing projects that can exploit space. In October, the shuttle will launch another Spacelab mission for West Germany. We welcome the stimulus of competition from our allies in the space research arena. We note, however, that unaided American businesses have difficulty competing against sovereign nations, and space ventures are not exception.

These international competitors are interested in space because they foresee the imminent advantages. In a few weeks the first made-in-space product will go on the market—tiny latex spheres manufactured on the space shuttle which will be used to calibrate sensitive instruments. Attention is being focused on space commercialization opportunities by major news publications. Recently articles have appeared in The Wall Street Journal and U.S. News & World Report on industrial space investments.

If current opportunities look appealing, you "ain't seen nuthin' yet". McDonnell Douglas and Johnson & Johnson have teamed up to experiment with a separation process called electrophoresis. Unlikely companies as Deere & Company and 3M are signing Joint Endeavor Agreements with NASA to explore materials processing concepts. With an operational, permanently staffed space station this trickle of interest will become a flood.

Many countries would gladly cooperate with America—rather than compete—as long as we have a program on which to focus cooperation. However, these countries will become impatient and go their own way if we delay our programs or study them to death.

"It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow."—Robert Goddard

Space offers a unique environment for research. The qualities of space include weightlessness (or more accurately microgravity), plentiful vacuum, freedom from contaminants, abundant sunlight, and access to extremely low temperatures. It is difficult to think of a physical or biological science that will not profit from research performed in space. Some features of the space environment can be emulated on Earth with great expense and difficulty, but one—microgravity—is simply not available on the ground. The NASA space station should be viewed as a National Laboratory for research on microgravity and other space processes.

Such a laboratory is needed. Most companies will not invest in projects that require more than three years to produce a marketable product, especially in high-tech industries, because of the perceived risk of breakthroughs in competing technologies. A fully capable, permanently manned space station will greatly reduce both lead times and costs.

One industry study on the space manufacturing of crystals used in constructing semiconductor chips estimated that it would take up to six years to develop the product on the space shuttle, but that the same product might be developed in only one year on a manned space station because of the opportunity for frequent and varied experimentation. This disparity is due to the relative amounts of time actually spent in research. A shuttle mission allows about a week of experiments if all the equipment works, so there is little time for pursuit of interesting leads. After analyzing results on Earth, new experiments must be assembled and scheduled for flight. This drags out the product development cycle.

Since the best research must be continually altered as it progresses, it is essential that this National Laboratory should be permanently manned. A station merely man-tended will not permit the creativity required in a laboratory. In an intermittently tended facility, shuttle visits would be mostly devoted to installing new experiments and servicing the station, leaving little time for science. Automated experiments could be conducted between shuttle visits, but some will be delayed by the inevitable breakdowns. Interesting leads will not be pursued until the next shuttle visit allows the experiments to be reconfigured.

Experience gained on the space shuttle reinforces the need for people in space. Last August, astronaut Charles Walker, industry's first private payload specialist, saved an important drug processing experiment. Shortly after starting, the experiment malfunctioned. With constant attention by Walker about 80% of the expected yield was obtained. McDonnell Douglas managers state that without Walker the product return would have been minimal or a total loss. Similarly, after the first Spacelab mission Karl Knott, project scientist for the European Space Agency stated, "What impressed me was the flexibility shown in the science operations. We had more than 200 replanning requests and close to 800 operation change requests from the investigators during the course of the mission."

A fully automated laboratory that can reconfigure and repair itself is simply beyond our present capability. Keeping scientists on the scene, however, is within our capability. Astronauts aren't cheap but machines alone won't work.

There is another advantages to a permanently staffed station: a broader spectrum of users. In an unmanned situation, each experiment must be designed and built for maximum reliability and autonomy. This is prohibitively expensive for anyone but governments and the largest companies. With astronauts present, the demands on experiments are reduced. If a lightbulb burns out, it can be replaced; if conditions change, an astronaut can reprogram the experiment. This lets experiments be much less expensive, so small businesses and Third World governments would be able to afford space research. We believe that access by a large pool or researchers is vital to insure that space research has a wider range of benefits. This access will be denied if we build an automated or man-tended space station.

As is clear from the examples above, the biggest role for space station research will not be the tradditional space sciences such as solar observation or planetary science, but new (for space) fields like materials science, biology, chemistry, and medicine. Because these fields will have more immediate applications than the traditional space sciences, their growth will be more rapid, with early results attracting new investments. Such products as life-savings medicines and new generations of computer chips will have a positive impact on our lives in just a few years.

History suggests that even greater benefits will come from the advances we cannot foresee. Few foresaw a decade ago the impact of personal computers on our world. The great discoveries of materials processing in space will not be made while our thinking is still bound to conditions on Earth. Only by investing in research can be learn to use this new environment to our advantage. THe development of these new space sciences will help to establish leadership in fields such as automation, electronics, communications, and aerospace.

"Never put off till tomorrow what you can do today."—old American axiom

At the moment, there is intense interest on the part of both private enterprise and our allies in participating in the space station project. Despite the Soviet Union's greater experience in long term orbital missions, the United States is still recognized as the world's leader in space technology. Proceeding with the space station will create an opportunity of broad participation and a general sharing of cost.

But if we expect other nations and private ventures to participate in the program, we must maintain a stable program so that our partners can plan their role. Any delay in the program will increase the chance that the European Space Agency or Japan will commit their resources to their own projects rather than wait for the American effort. Likewise, delay in the program is apt to result in business resources being committed to other projects.

The office of Technology Assessment in its recent study on Civilian Space Stations found that U.S. private sector sales from space average $2 billion a year and by conservative estimates will grow by an annual rate of 15% per year. In 20 years the tax revenues from this growing business may well pay the costs of the entire civilian space program. According to a 1983 TRW study "more revenues are produced annually from users, builders and sellers of communications satellities and services than the total NASA R&D investment in comsats during the 1960's." Our investment is paid back every five years in taxes.

The space station is America's seed stock, our opportunity for tomorow. When the Chrysler Copporation faced bankruptcy and slashed its budget to be bone, two things which were not cut were Research & Development and money for retooling its plants.

The nations that seize leadership in tomorrow's technologies will lead the world into the 21st century. America's part in that future is not guaranteed. Columbus was Italian—but he sailed for Spain because he could not interest his own nation in these new trading opportunities. And, inevitably, the economic and political power of the Italian merchants waned as the traditional overland routes from Asia lost out to the sea-based trading with India and the New World. The United States can also choose to become a secondary economic power, or we can take the necessary steps and make the necessary investments to continue our leadership.

As one foundation for the next century's national economy, we suggest that the leaders of America view the space station as an enterprise of great urgency. The monthly imbalance of trade payments is greater than the entire planned investment of $8 billion for the space station. No other government investment will go so far in creating jobs, advancing technologies, and improving the quality of life here on Earth.

The space station is not just a moneymaker, it is an industry-maker. The facilities we build today will underpin a new space industry to meet humanity's needs, and will provide a foundation on which to build for the challenges ahead. Like the railroads, Grand Coulee Dam and the Tennessee Valley Authority, the space station will provide the infrastructure needed for successful development. The sooner the space station is available, the sooner we can begin to reap the benefits. We ask that you support funding for the space station and that you seek and implement ways to hasten its opening.

STATEMENT OF MICHAEL T. LYONS, VICE PRESIDENT & GENERAL MANAGER, SPACE RESOURCES DIVISION, SATELLITE BUSINESS SYSTEMS

On behalf of Satellite Business Systems (SBS), thank you for the opportunity to share with the Subcommittee our opinions on pricing policy for the Space Transportation System (STS). SBS has a profound interest in the direction of U.S. Government policy decisions regarding Government and commercial launch services.

SBS is a nationwide and international communications company owned by IBM and Aetna Life and Casualty. In fulfilling our corporate role we have been, and will continue to be, a major user of launch services. SBS has four satellites in orbit; two employed the Delta launch vehicle and two employed the STS. In fact, the SBS-3 satellite was the first operational satellite deployed by the STS. All of our launches have been totally successful and we are understandably enthusiastic about the quality and reliability of the NASA launch organizations. SBS has developed a special perspective on the evaluation of different launch systems, based on these past experiences, on our more recent experience in negotiating a launch contract for our fifth spacecraft, and on our current negotiations on our sixth spacecraft launch.

From an operational point of view, the STS vehicle is the primary workhorse which SBS would prefer to depend upon to provide its spacecraft transportation to orbit. We prefer this vehicle because of our assessment of its reliability and, flexibility, because of the quality of the team that provides launch services for the spacecraft, and because of our pride in this national resource.

Notwithstanding the SBS operational preference for the STS as its primary vehicle, we endorse the need for an alternative vehicle. In support of this consideration, we elected to employ the Ariane vehicle for our fifth launch, with the STS as a potential backup. SBS selected Ariane principally due to a concern with balancing the risk and minimizing the dependency upon a single launch vehicle to provide much needed capacity in the 1986/87 timeframe.

In the process of selecting the Ariane launch vehicle in April of 1984, SBS had an opportunity to assess the relative benefits of the STS, Ariane and the Delta vehicle, as provided by Transpace Carriers, Inc. At the time of that competition the Ariane and the Transpace Delta were directly competitive with each other with respect to price, and the STS was significantly higher. While price was not the primary motivation in SBS's decision to select the Ariane, it was certainly a significant factor. Although the Transpace price was directly competitive with that of Ariane, the price was contingent upon Transpace being able to obtain two additional users of the Delta vehicle in order to assure a viable program. SBS has flown the Delta vehicle on two occasions and has an extremely high regard for the quality of the vehicle, and of the operating team which Transpace was proposing to employ for the launch. However, recognizing the absolute requirement for SBS to be able to formulate a firm business plan with fixed cost and schedules for the delivery of the desired communications capacity in a timely manner, the Transpace offer was deemed substantially less attractive than that of Ariane.

It is our belief that long term institutional backing and the assurance of a reasonable annual launch rate are essential to the establishment of commercial viability, and appeal, for commercial expendables. As an example of the type of institutional backing that is now available, the Ariane 3 vehicle is currently being provided by Arianespace, and the larger capacity Ariane 4 vehicle will be flown in 1986. In addition, Arianespace, in conjunction with the French Government, is sponsoring an Ariane 5 development. Thus there is sustained program by Arianespace to meet both the current and future needs of the user community. This has, in fact, established a base against which others will be compared.

This brings us to the remaining, but substantial, issue of price. Reliability and availability are prerequisite criteria for choosing a particular launch vehicle, but price has an even broader impact. The prices of different launch services obviously helps a customer decide which one to buy. In addition, however, the price of launch services also plays a major role in encouraging or discouraging the commercial development and use of outer space.

In the telecommunications area, for example, this happens to be a particularly critical time when companies are looking at the relative merits and costs of future investments in satellites or terrestrial facilities. In our view, at the present time the relevant costs in many areas are roughly comparable or generally balance. However, an artifical increase in the costs of launch, especially if it is not tied to the real costs or to an increase in the value of the service, could well have a significant adverse impact on the case for using outer space. This bias could apply in other areas as well, such as scientific and product manufacturing activities.

It is, therefore, extremely important that any changes in Government policy on launch pricing should take into full account the potential impact on the future commerical development of outer space resources, as well as the impact on the relative competitive positions of different launch vehicles and services. Neither the Government nor industry can afford to be short sighted in this regard. The outcome of the current debate on launch pricing will, in fact, have consequences far beyond the choice of launch services; it will affect the basic decision whether to launch at all. The pricing policy decision is, therefore, tied closely to the public policy on encouraging the development and use of the resources of outer space.

SBS has raised these considerations in conversations with Government officials who are participating in this policy review. In addition, we are actively participating as a member of the Commerical Space Transportation Advisory Committee of the Department of Transporation. The staff and members of that Committee have initially focussed on the roles and present costs of the STS and existing expendables. We believe it is now equally important to focus as well as on the impact of pricing changes on the user community, which, after all, is going to be the basis for commerical viability of any of these vehicles. We have submitted a letter to the Department of Transportation expressing our concerns. Our letter, of November 12, 1984 is being submitted as part of the SBS written statement.

Based upon the above consideration, it is our strong recommendation that the STS price be established at a level consistent with the recovery of the additive costs of the launch service. In proposing this price structure, we are reflecting the basic realities of the STS program; it is a national resource, and for the United States to pursue its space related objectives, the STS will be funded as an operational system. As a consequence, there is a fixed minimum annual funding level associated with sustaining the operational, engineering and training efforts. SBS does not believe it appropriate that commerical STS user should bear these costs. We do, however, agree that we and other users should share proportionally all costs directly associated with the specific flight. These costs would include NASA engineering support, all consumables and expendables, and direct mission support.

It is SBS's belief that a proper accounting of these costs will yield an STS launch price that fairly recovers the U.S. Government investment, and would allow the STS to be competitive with alternative foreign launch vehicles such as the Ariane. In addition, it would establish a fair market base on which other expendable launch services could measure their own competitive viability.

We further believe that this policy is most consistant with maintaining the United States as the world space leader, and providing for the U.S. people the maximum opportunities and benefits of space research and commerical space operations. Thank you Mr. Chairman for this opportunity to express our views.

STATEMENT OF ROBERT K. RONEY, VICE PRESIDENT, HUGHES AIRCRAFT CO.

Chairman Gorton, members of the Committee, ladies and gentlemen: I am very pleased for this opportunity to speak to you today, and to give my views on Shuttle pricing policy from the perspective of a user who both builds and operates communications satellites.

First, let me say we are very sympathetic with the interest in promoting the free enterprise commercialization of space. In fact, the commercialization of space is not a new concept. It began 20 years ago with the first commercial communications satellite, Earlybird. Since that time it has grown to a multibillion dollar industry with billions of dollars in space assets, yielding nearly $1 billion per annum in revenues to American spacecraft manufacturers alone, with comparable amounts for space transportation and for value added services by communications operators. Nearly 40% of these spacecraft sales are into the export trade. Spacecraft is one of the few markets in which the United States enjoys a favorable balance of trade for manufactured products.

This flourishing business has been nurtured by the relatively economical access to space provided by NASA over these 20 years. In recent years NASA has faced foreign competition in space transportation, which, though directly adversely affecting the U.S. trade balance, has overall been stimulative to the communication satellite market by slowing the upward spiral of space transportation costs.

As both a builder and operator of communications satellites, my company is keenly interested in anything that affects the economy of satellite communications. Thus we welcome the prospect of American commercial ELV services. But we are deeply concerned that in the interest of promoting an emerging commercial space enterprise the government may adopt policies that could strangle an existing thriving enterprise.

The cost of transportation accounts typically for about one half the total capital cost of communication satellite. Thus the economics of satellite communications is vitally sensitive to the cost of launches. For the purposes of the communications satellite traffic, the viability of any space transportation system hinges not only on its pricing relative to alternative transportation systems, but also relative to the cost of alternative communications technology.

By way of illustration, a standard commodity unit of satellite communications today has become the fully backed-up 36 mhz C-band transponder in the U.S. domestic service. This unit is facing considerable market resistance at a $6 million sales price. Every $50 million increase in transportation cost of a dedicated shuttle will add $1 million to the cost at that transponder. It is impossible to say at what transportation cost the satellite market would totally disappear, as different elements of the market will have different break points, but it is clearly an elastic market. Even today some markets in which satellites have heretofore prospered are showing increasing competition from terrestrial means, especially with the growing capabilities of fiber optics.

So, where does that bring me regarding shuttle pricing policy? It should be clear that communications operations need the lowest price that is practicable. This interest must be reconciled with the public interest in "full recovery" of launch services cost. The issue is; what costs are to be fully recovered? For purposes of commercial satellite launches, I submit that the costs to be "fully recovered" should be the additive costs for the commercial mission. I base this position on two arguments:

The first argument is one of fairness. That is, much of the cost of operating the shuttle stems from its status as a manned flight vehicle. I have detected no perception among communications operators of any operational advantage from the special characteristics of the shuttle. In fact, on the whole, the operational problems of using the shuttle have a negative appeal relative to the convenience of a dedicated expendable rocket. So it is unfair to charge any of the cost of maintaining the manned spaceflight program for the service of simply transporting a payload to orbit.

The second argument is one of the public interest. First we must decide as a matter of policy why we want the shuttle program, and why it matters whether it beats the ELVs, either foreign or domestic.

Do we need the shuttle for (a) its fundamental capabilities not attainable from an ELV, i.e., for a national objective not justified simply on utilitarian economic grounds?; or (b) do we need it for its superior economy for space transportation? If it is the latter, then continuation of the shuttle program must stand on the validity of that proposition. Its economy would be tested by absorption of all cost associated with its operation by charges for cargo transportation.

If, as I believe, our purpose for the STS is to serve national objectives related to its fundamental characteristics, a matter of national pride, of man in space, research into the unknown, a step toward the space station and beyond, then the justification for existence and maintenance of the basic capability has nothing to do with relative economy. Its basic cost will be incurred and justified for that purpose without regard to any routine transportation traffic. It then certainly becomes appropriate to consider additional, non-national uses simply on the basis of whether that use is marginally economic.

If it is not marginally economic, such additional business should be allowed to go where the economics dictate.

On the other hand, if the market, as constrained by demand elasticity or competitive launch vehicles, will support a price above the additive costs, use of the shuttle should be priced competitively to that market so as to maximize the product of payloads captured times the marginal return. This will maximize the total net return to the taxpayer, or minimize the unrecovered cost of the shuttle program.

It is beyond my competence to settle where that price will be, but I am sure it must be well below the so called "full recovery" of all shuttle operating costs, especially in the event NASA falls short of its launch rate goal. That optimum price will also likely be below the price of an equivalent ELV, for as I have said, on the whole, the operational problem in using STS have a negative appeal as compared with the convenience of a dedicated expendable launcher. The overwhelming positive repeal of the shuttle has lain in its price advantage, relative to alternative launchers. Commercial success of the STS hinges on continuation of this margin.

This concludes my statement. I thank you for this opportunity to give my views.

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